EDUCATIONAL TECHNOLOGY: COMPUTER-BASED INSTRUCTION

HEARING

BEFORE THE

SUBCOMMITTEE ON
TECHNOLOGY AND COMPETITIVENESS

OF THE

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SCIENCE, SPACE, AND TECHNOLOGY
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EDUCATIONAL TECHNOLOGY: COMPUTER-BASED INSTRUCTION

TUESDAY, JUNE 18, 1991

U.S. HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON TECHNOLOGY AND COMPETITIVENESS,
Washington, D.C.

The subcommittee met, pursuant to call, at 9:40 a.m., in Room 2318, Rayburn House Office Building, Hon. Tim Valentine [chairman of the subcommittee] presiding.

Mr. VALENTINE. Ladies and gentlemen, we'll get started.

In some cases, our schools are far and away the most comprehensive and expensive information and knowledge transfer system in our Nation.

Yet, for the most part, the information revolution has passed them by. Despite increases in the number of classroom computers, occasional CD-ROMs and a few information technology experiments, today's students are being taught largely in the same way that their parents and grandparents were taught.

Yet, the past decade has seen the emergence of wondrous new technologies that have changed the way that we live and work and should be permitted to change the way that we learn.

New technologies which could have a major impact on education, hit the market every year. For instance, the high definition systems we discussed in hearings in May could spark a revolution in education just as rapidly as it might in home entertainment.

Through educational technologies, instruction from experts in academia, business, and government could conceivably reach students in the most remote parts of our country. Scientific experimentation, usually performed on high-cost equipment and instrumentation, could be simulated on classroom computers at a fraction of the cost. And the abstract theoretical concepts of the basic sciences and mathematics could be presented on the computer screen interactively in a way that students could easily visualize, manipulate, and thus understand.

President Bush has asked that innovative approaches to education be given special attention and has called for model schools in every congressional district. He has given us a broad outline of his new vision, but, as of yet, few of the details to guide us.

My hope is that the Congress will be willing and able to work with the administration to add some substance to the proposal and explore the potential that modern information technology has to offer the education of this Nation's young people.

Today we're honored by having an outstanding group of witnesses. I'm pleased to say that our key education agencies, which are represented here today, understand the promise that technology holds in shaping the classroom of the future.

I'd like to welcome especially Dr. Walter Massey, who is the Director of the National Science Foundation; and Mr. David Kearns, who is the new Deputy Secretary of Education, and former Chairman and Chief Executive Officer of the Xerox Corporation.

Dr. Massey and Mr. Kearns, we have all heard, of course, excellent things about both of you; some as recently as a few minutes ago from Dr. Ritter. And on behalf of the subcommittee, I would like to extend a special welcome to you and I sincerely hope that our future cooperation in addressing the Nation's problems will be fruitful and make a substantial difference.

In addition, Dr. Linda Roberts from the Office of Technology Assessment, who is a distinguished expert in this field, will be with us today and testify.

We also have Dr. Ronald Fortune, who is President of Computer Curriculum Corporation in Sunnyvale, California; Mr. Albert Shanker, President of the American Federation of Teachers.

And we also have my very good friend, Superintendent of Johnston County Schools in the State of North Carolina, Dr. Thomas Houlihan.

We have Mr. Jeffrey Joseph, Vice President of Domestic Policy for the United States Chamber of Commerce.

And let me say before I go much further, to Dr. Houlihan, that given the proceedings that are under way in the North Carolina General Assembly having to do with a topic which is near and dear to the heart of most Members of Congress, known as redistricting, we might be together again.

And Dr. Leroy Tuscher is Director of Educational Technology and Professor of Technology and Computer Science at Lehigh University.

I look forward to hearing firsthand what educational technology can do today and what it might do in the future—all of us on the subcommittee do.

I'd like to explore with the witnesses what the Nation—from the Federal level to the local level—can do to take "technology in the schools" from concept to commonplace.

I'd like to make just two more comments before recognizing our distinguished colleague from Florida. I'm pleased to announce that we will have a special group of guests with us today—Calvert County students from the congressional district of the gentleman from Maryland, Mr. Gilchrest, and students from Prince George's County are present—or will be present—to demonstrate some of the computer technology and show us exactly what kind of role technology plays in educating our young people.

I'd like to encourage members, staff, and others who are here today to attend the demonstration, which is to begin immediately after the conclusion of this hearing.

And, finally, as talented and informed as our witnesses today are, I expect that there are opinions in this audience which will not be expressed by them. One of the functions of congressional hearings is to build as meaningful and complete a hearing record as circumstances permit; therefore, I would like to extend an invitation to those present and others who may know of these proceedings that you may make your ideas, on the subject before us, available to the committee and submit them over the next 10 days for inclusion in the hearing record.

And at this time I recognize the distinguished Ranking Member of the subcommittee, the gentleman from Florida, Mr. Tom Lewis.

Mr. LEWIS. Thank you, Mr. Chairman.

I welcome Dr. Massey and Mr. Kearns and the other witnesses.

The quality of science and math education has been an area of major concern of mine for many years. And I think that the need to improve education has never been greater.

Last year, the National Assessment of Educational Progress conducted a study of math ability in grades 4, 8 and 12. The results of the recently released report showed that only 14 percent of the 8th graders scored at the 7th grade level or above.

Equally alarming was the assessment that only 46 percent of 12th graders can do 7th grade math work.

Why the dismal showing?

A popular news magazine concluded that one reason was that about two-thirds of today's students had never used a computer in math class.

Continuing the analysis, the magazine stated: Educators say too many children are wasting time practicing adding, subtraction, multiplying and dividing, when they could be moving on to more interesting and challenging math.

Another publication, Space News, ran an editorial stating that poor science and math skills keep young Americans from pursuing technical careers.

An example was given of a major U.S. employer that rejects up to 90 percent of its entry level applicants because they cannot meet a 9th grade math skills requirement.

Are the conclusion reached in these articles correct?

I hope today's witnesses will address the issue of whether technology, such as computer-based instruction, is the answer to better quality learning by our math and science students.

And, Mr. Chairman, I want to express my appreciation to you for calling this important hearing. And I also want to congratulate the gentleman from Maryland, Mr. Gilchrest, for his interest and foresight in requesting this hearing and demonstration on technology in education.

Thank you, Mr. Chairman.

Mr. VALENTINE. Thank you, sir.

The Chair recognizes at this time the distinguished lady from Missouri for any opening statement, Ms. Horn.

Ms. HORN. Thank you, Mr. Chairman, and I do have a statement to submit for the record. But let me just say a couple of words here.

I know that this computer-based instruction is a wonderful thing. In my district, we are fortunate enough that most of our schools do have computers. I have some interns in my office this summer who are in college now who have had access to computers since they were in kindergarten. So this is not exactly the cutting edge of technology.

I'm also aware that in my relatively affluent district, we have things that other schools do not have. And that there are many schools in many States, and even in my State—nearby schools—that do not have these kinds of technologies.

They are wonderful things. We have a facility that opened recently in our area in St. Louis that you would perhaps love to visit. It's the classroom of the future, it's a multimillion dollar facility that takes classroom technology to an edge that really is wonderful, but is way beyond the means of most school districts at this time.

They do make it available for school visits—field trips by the schools. And teachers can come in and program for their own districts, for their own classrooms. So it is a wonderful facility and I expect you'd like it very much. It's part of the St. Louis Zoo—it's called the Living World Building there, and is a wonderful classroom of the future. Very high tech, with some very specialized kind of programming, specializing in the life sciences and in the zoology areas.

Our computers are fun. They give the kids something to do, allowing the teachers to do other things. They have great promise for us in the areas mentioned by the chairman, the Ranking Member, and I have great interest in this area, and I'm very delighted to have these prestigious witnesses with us.

Thank you, Mr. Chairman.

Mr. VALENTINE. Thank you.

The Chair recognizes at this time the distinguished member of the subcommittee from Pennsylvania, Dr. Ritter.

Mr. RITTER. Thank you, Mr. Chairman. And I want to congratulate you on yet another in your continuing series of timely hearings on how technology can contribute to the improved competitiveness of American industry and American workers.

I also want to commend the gentleman from Maryland, Mr. Gilchrest; and also in particular, the gentleman from Pennsylvania, the Ranking Member of the full committee, Mr. Walker, for his strong interest in this subject and being to some extent, the motive force in the formulation of the hearing.

Our witnesses today will discuss innovative uses of computer and information technology as a means of enhancing the quality of America's educational processes.

Our education system is a key supplier to all other sectors of our economy. But as we continually hear from the customers of our public education system, in particular, the employers, it's simply not adequately preparing us for today's global competition.

As if the acknowledged math and science illiteracy problem weren't enough to cope with, there's far too much English language illiteracy; and foreign language study is just about off the radar screen.

On top of all this, we have to prepare an entire new generation of scientists, engineers, technicians and workers for the factories and offices of the future. The nation's educational remediation bill, to date, is enormous, as American businesses pay huge sums to educate and re-educate employees who did not get near enough in our public schools.

Thus, as the United States fights back in its battle to regain its international competitive edge, improving America's educational system is certain to be one of the preeminent challenges we face in the coming decade.

When it would seem that a natural strategy would involve applying America's comparative strengths in information and communications technologies to what is emerging as one of our most formidable vulnerabilities—the education of our young people and employees.

Mr. Chairman, I'd like to welcome our distinguished witnesses and look forward to their testimony. I would like to mention that David Kearns is uniquely qualified to be Deputy Secretary of Education in these difficult times. As the Chairman and CEO of the Xerox Corporation, he led them from certain death, using the principles of the quality revolution to bring Xerox to a Malcolm Baldridge National Quality Award a couple of years ago, and primacy, and in the great majority of the products that face very stiff global competition.

He is also the author of the book, "The Brain Race," which outlines a host of strategies necessary to bring America's educational system up to par.

So with that, I yield back the balance of my time, Mr. Chairman.

Mr. **Valentine**. Thank you, sir.

The Chair recognizes at this time the gentleman from New Hampshire, Mr. Dick Swett, who will preside over the subcommittee from around 10:30 this morning until around noon.

Mr. **Swett**. Thank you very much, Mr. Chairman.

I will inform you first and foremost, I have a quick meeting between 10 and 10:15. So if I leave directly after my statement, don't feel that I'm leaving you in the lurch—I will return.

I'm very excited about an important hearing that we will be having this morning. And I commend you, Mr. Chairman, on your leadership on this issue.

The education of our children should be a top priority of our Nation. Our workplace has changed much more drastically over the past 100 years than our classrooms. If we are to remain competitive , we must train our children so they are able to respond to the challenges they face in·today's workplace.

The problems with the current system are not the fault of the teachers or the administrators. The problem is that they lack the tools they need.

How can science teachers expect to teach about science in the 1990s without the ability to show the students what computers do.

Mr. Chairman, my commitment to this issue is personal. Since my election to Congress, I have made it a point to teach a class in every school in my district once a week. By the end of the Congress, I hope to have taught in every school in my district.

And I'll just add my comment to what my good colleague, Congresswoman Kelly Horn has said. Unlike her district, I have traveled through many of the schools in my district and have not found computers and have not found current technology. And I think that this is something that needs to be corrected.

I'm very interested in finding out how that can be done through the programs we'll be discussing this morning.

I often talked about environmental and energy issues in these sessions that I have with students because of my strong belief that we must foster a commitment to these important issues at a very young age.

Through this effort I have seen how valuable a computer for every student should be.

Mr. Chairman, I am looking forward to hearing from our distinguished panel of witnesses—and I thank you for this time, which I yield back what remains of it.

Mr. VALENTINE. I thank the gentleman.

That's an ambitious undertaking. I am still trying to get a flag to every school in my district and not able to do it.

[Laughter]

Mr. VALENTINE. I want to say that the gentleman's undertaking is worthy because he's well qualified. I would like to say to my colleagues, if too many of us tried that, it might be the end of public education.

[Laughter]

Mr. VALENTINE. I recognize at this time the distinguished new Member of our subcommittee whose younger constituents I referred to earlier—Mr. Wayne Gilchrest.

Mr. GILCHREST. Thank you, Mr. Chairman.

Welcome, Dr. Massey and Mr. Kearns; we look forward to your testimony.

I want to welcome the young people from Calvert County this morning, and I look forward to the demonstration later on today.

Computers and computer technology in the public schools will not be the panacea for the educational system in the United States unless we also understand the purpose and the function of education.

It's to prepare students and young people to be able to apply, once they leave school, what they learned in school, and they will be able to apply this knowledge to whatever type of technology exists in their neighborhood at the time.

In order to teach children adequately—whether you have the technology or whether you don't have the technology; and technology can be a tremendous advantage if you somehow capture that natural sense of curiosity that children have. And if you capture that natural sense of curiosity, and you use the technology and the human interaction to motivate what it is that you know they need to do, then you have started the foundation of their education.

And once you've started the foundation of their education, and they know what they learn in school can be applied outside the schoolhouse door, then you've taken another step.

If you make that information you are giving to those students challenging—challenging to those young minds—then they're going to go with it.

If you make the classroom such that they can participate—not just sit there and listen, but actually participate—then you're moving in the right direction again.

If once they participate they get a sense of accomplishment—that's another proper move.

If what you give them is moving in intellectual and in an emotional sense, it is moving because people that learn don't just learn from machines, they learn as human beings, and human beings have emotions, and they have senses, and they have spirits—and if you can touch that with the educational curriculum, then you're doing something.

If it can be rewarding, every single day is a rewarding experience, and if it's a valuable experience—emotionally, spiritually, and it can be applied outside the schoolhouse door. It's going to be worthwhile, and I suppose that's the last thing when teachers create curriculums and lesson plans; they can have all the technology in the world, but if those characteristics that I just described are absent, then there will not be learning.

If all of those things are applied, I think the learning will be worthwhile. And don't forget, these kids are not like machines where you can adjust it, you can put a screwdriver in there, you can throw another chip in there. These are human beings that have some sense of worthiness, and if you can convey to them that they are worthy and that what they're learning is worthwhile, then these computers are going to do miracles in the classroom.

Dr. Massey and Mr. Kearns, I look forward to your testimony.

And welcome, people from Calvert County. This is a great place, Washington, D.C.

Thank you, Mr. Chairman.

Mr. **Valentine**. The Chair recognizes at this time for an opening statement, the Ranking Member of the full committee, the gentleman from Pennsylvania, Mr. Bob Walker.

Mr. **Walker**. Thank you, Mr. Chairman. And I would like to join with you in welcoming our guests here this morning, and particularly those who bring us testimony.

As a former teacher myself, whose wife is currently the Director of Curriculum in the Lancaster City Public Schools, I do have a special interest in today's hearing.

Indeed, computer-based learning has been the subject of intense concern to this entire committee for sometime. Following up on numerous hearings, this committee, last year, wrote a provision into the Excellence in Science, Mathematics, and Engineering Act, which the President signed into law, our language authorized greater NSF effort in computer-based and distance learning.

I am pleased that we have witnesses here today from NSF and the Department of Education because both agencies have ongoing programs that should be working together to create new software, curriculum and teacher training programs.

I'll be interested to hear how all the programs fit in with the President's new education initiative.

We need to understand how these existing efforts can yield greater results in the classroom.

Every teacher dreams of the ideal or so-called socratic teaching environment, where there's a 1-on-1 relationship between a skilled teacher and a willing student. This, of course, for many reasons, has not been possible where a large number of students must be taught simultaneously. Such is the dilemma of our contemporary education system.

Children learn individually, but are taught in groups, often meaning that we are teaching to the lowest common denominator.

With the advent of the computer, we see the first signs that our goal of a socratic learning situation for each individual student may be attainable. Computer-based learning relieves the teacher of the relatively mundane task of simply dispensing instructional material. Instead, in a new role of a real educator, he or she, in close consultation with parents, assembles, and implements, curriculum packages tailor-made for each student.

The educator then monitors the progress of each student closely, making adjustments to the individualized curriculum packages as circumstances dictate.

The system would also provide more time for individual consultations with the students and management of their student peer activities, including much more interaction between the students themselves.

Mr. Chairman, I wish to congratulate you for your foresight in putting together this hearing on computer-based learning and for the outstanding qualifications of the witnesses you have assembled.

I realize that we still have a lot of hurdles to clear before my wife and I and other educators will see our dream of individualized instruction come true. But we should do everything we can do to move it along. The future of our country may well depend upon it.

Mr. VALENTINE. Thank you, sir.

I recognize at this time our colleague from California, Congressman Dana Rohrabacher.

Mr. ROHRABACHER. Mr. Chairman, thank you very much and, again, congratulations to you. You've been very innovative in the subject matter of this committee, and I congratulate you for it.

In terms of education, I think that we've—well, we've basically got two challenges, as far as I can see. One is to make sure that America reaches its potential and that those young people who are capable and have the right kind of background and support systems reach their potential so that America can reach its potential. And certainly we live in an age of technology and that means these kids have to be able to understand computers.

Frankly, I am less concerned about that and American competitiveness in terms of education than I am about a generation of lost Americans that we seem to see emerging among us, and that is a whole generation of young people in our inner cities and from the underclass that can't write and can't read and can't do numbers.

And I am just horrified in the realization that many of these young people who are left out of this society are very bright young people. They're very bright kids, and they have tremendous potential in themselves in the beginning, only they just never get beyond the first step because they never learn to read, or they never learn to write.

Many of the young criminals that are victimizing other citizens in our society, when you come to find out, they can't read, and they can't get any other jobs, and they can't do numbers, they can't do basic math. And I'm very concerned about these kids because they're going to be with us for the rest of their lives.

And like many of the other problems facing the United States of America, we've seen that technology has a role in solving some of the basic problems. As a matter of fact, America has already turned to technology for some of these—for answering some fundamental problems in our society like pollution, et cetera, and certainly an education.

It seems to me that our education system, much of it is still like it was a hundred years ago. I would think that education and technology can come together to try to meet this challenge of teaching the basic educational skills of reading, writing, mathematics, to the young people who are right now being left out of the system.

And I'm anxious to hear your testimonies, especially concerning how technology might be able to teach these young people who are not being equipped today but being able to equip them so that they won't be left out in the future.

Thank you, Mr. Chairman.

Mr. VALENTINE. Thank you, sir.

The lady from Maryland, Mrs. Connie Morella.

Mrs. MORELLA. Thank you. Thank you, Mr. Chairman. I appreciate also your setting up this meeting, and Mr. Gilchrest having the students to demonstrate it, and the very distinguished panel that we have before us.

We give opening statements because we want you to know in advance of our interest on the subcommittee and what we are going to be hearing.

I am particularly interested in this hearing, Mr. Chairman, as a former educator myself, and the subject is of great interest—educational technology and computer-based instruction.

Educating our citizens is pivotal in our ability to compete globally as a world power, while also providing the basis for our future development.

Methods to enhance the American educational system have always been a concern of mine, and I'm looking forward to hearing about the potential for computer-based instruction as a means to improve and to update our learning system into the 21st century. The word "education" comes from two Latin words, meaning to lead from, lead from ignorance into enlightenment.

As the committee begins to explore this area of educational technology, we must look carefully into our current system and identify areas in need of advancement, as well as determining what is currently effective.

As the traditional system is evaluated, we can then decide where computers can address areas that our system neglects, thereby enhancing the learning process.

The introduction of computer-based instruction would undoubtedly have a great impact on the traditional classroom, in areas such as the teacher/student relationships. And I think we must be very much aware of that. We must not ignore such change and we must be able to recognize the possible detrimental effects to the student.

The question of how far the computer can go in the classroom is a particular concern, and a challenge. It has been suggested that it could replace the teacher—a concept, I believe, that necessitates very careful study.

Can a computer adequately replace all aspects of human instruction?

The benefits of computer-based instruction must be weighed against the costs—both in financial as well as human terms.

Is the benefit so much greater than our traditional system that we can afford any cost?

As we enter the 21st century, our schools must keep pace with advances in technology.

I'm looking forward to hearing how computers can accomplish this goal.

And I am again very pleased to welcome our distinguished panel and look forward to hearing their testimony.

And to the people from Calvert County, Washington is a great place, but so is Calvert County because I just bought some property there.

Thank you, Mr. Chairman.

[The prepared statement of Mrs. Morella follows:]

Constance Morella

CONSTANCE A. MORELLA

SST/T&C

JUNE 18, 1991

THANK YOU, MR. CHAIRMAN. AS A FORMER EDUCATOR, I SPEAK WITH PARTICULAR INTEREST ON THE SUBJECT OF TODAY'S HEARING CONCERNING EDUCATIONAL TECHNOLOGY AND COMPUTER-BASED

INSTRUCTION.

EDUCATING OUR CITIZENS IS PIVOTAL IN OUR ABILITY TO COMPETE GLOBALLY AS A WORLD POWER WHILE ALSO PROVIDING THE BASIS FOR OUR FUTURE DEVELOPMENT. METHODS TO ENHANCE THE U.S. EDUCATIONAL SYSTEM HAVE ALWAYS BEEN A CONCERN OF MINE, AND I AM LOOKING FORWARD TO HEARING ABOUT THE POTENTIAL FOR COMPUTER-BASED INSTRUCTION AS A MEANS TO IMPROVE AND UPDATE

OUR LEARNING SYSTEM INTO THE 21ST CENTURY.

AS THE COMMITTEE BEGINS TO EXPLORE THIS AREA OF EDUCATIONAL TECHNOLOGY, WE MUST LOOK CAREFULLY INTO OUR CURRENT SYSTEM AND IDENTIFY AREAS IN NEED OF ADVANCEMENT, AS WELL AS DETERMINING WHAT IS CURRENTLY EFFECTIVE. AS THE TRADITIONAL SYSTEM IS EVALUATED, WE CAN THEN DECIDE WHERE COMPUTERS CAN ADDRESS AREAS OUR CURRENT SYSTEM NEGLECTS, THEREBY ENHANCING

THE LEARNING PROCESS.

THE INTRODUCTION OF COMPUTER-BASED INSTRUCTION WOULD UNDOUBTEDLY HAVE A GREAT IMPACT ON THE TRADITIONAL CLASSROOM, IN AREAS SUCH AS THE TEACHER/STUDENT RELATIONSHIP. WE MUST NOT IGNORE SUCH CHANGE AND WE MUST BE ABLE TO RECOGNIZE THE POSSIBLE DETRIMENTAL EFFECTS TO THE STUDENT.

THE QUESTION OF HOW FAR THE COMPUTER CAN GO IN THE CLASSROOM IS A PARTICULAR CONCERN.

IT HAS BEEN SUGGESTED THAT IT COULD REPLACE THE TEACHER--A CONCEPT, I BELIEVE, THAT NECESSITATES VERY CAREFUL STUDY. CAN A COMPUTER ADEQUATELY REPLACE ALL ASPECTS OF HUMAN INSTRUCTION? THE BENEFITS OF COMPUTER BASED INSTRUCTION MUST BE WEIGHED AGAINST THE COSTS--BOTH IN HUMAN AND FINANCIAL TERMS. IS THE BENEFIT SO MUCH GREATER THAN OUR TRADITIONAL SYSTEM THAT WE CAN AFFORD ANY COST?

AS WE ENTER THE 21ST CENTURY, OUR SCHOOLS

MUST KEEP PACE WITH ADVANCES IN TECHNOLOGY. I AM LOOKING FORWARD TO HEARING HOW COMPUTERS CAN ACCOMPLISH THIS GOAL. I AM PLEASED TO WELCOME OUR DISTINGUISHED PANEL TODAY AND I LOOK FORWARD TO HEARING THEIR TESTIMONY.

Mr. Valentine. The Chair—

Mrs. Morella. There's no relationship to redistricting.

[Laughter]

Mr. Valentine. I don't know the districts in Maryland well enough to understand the humor of that, but I—I know that there would certainly not be anything in the lady's character that would suggest that she has an option, I understand, to own property in every other county in that part of that Maryland.

[Laughter]

Mr. Valentine. The Chair recognizes at this time the distinguished Member—a new Member who just joined us—the gentleman from Indiana, Mr. Roemer. Do you have an opening statement, sir?

Mr. Roemer. Thank you, Mr. Chairman. I'll be very, very brief. As always in Congress, we have three competing committees taking place at the same time and we have one going on with the Trio Upward Bound programs to enhance not only opportunities for young people from low income areas to get to college and not only to dream about it but to see those dreams come true and to succeed in college.

The other committee hearing that I need to get to is the Secretary of Education is testifying on the Administration's proposals. And I will take to both those committees the excitement that I have for what is taking place in this room; from the leadership of our chairman, and the Ranking Minority Member to have this committee hearing when technology is such an important aspect of our ability to both excite our young people and tap their potential and get them prepared to compete in a global economy with students in Germany and—and Japan that are also going to have opportunities to get exposure to this kind of technology and equipment.

And as the Persian Gulf war was taking place, I found that young people who were watching the news were very, very excited and asked all kinds of questions about the scud missiles and the Patriot missiles, and the F-117's. They want to know about technology. They're not intimidated by it yet. They want to work with it. They are excited about it.

And we sure know how often times how difficult it is to tear kids away from the Nintendo games and the Mario programs, and so forth, too.

So I am very excited about what we're going to hear today. I look forward to working with both Dr. Massey and Mr. Kearns and hearing their testimony and seeing what kind of potential, and how exciting this whole aspect is for the future of our country, both for our kids and for the competitive technology that we need to develop to compete in a world economy as well.

I'm anxious to hear your testimony. And then Mr. Kearns, I was reading about your predecessor last night on the plane in, Xerox, and I'm anxious to hear what you have to say in your experience in the private sector as well.

Thank you, Mr. Chairman.

Mr. Valentine. Thank you, sir.

I would ask the first panel and others, too, if you would please summarize in what time you think is necessary. Your prepared statements will appear in the record as presented to the subcommittee.

I failed, and I apologize, for this, I failed to warn the witnesses who are present that we had to testify first.

[Laughter]

Mr. **Valentine**. Dr. Massey.

STATEMENTS OF DR. WALTER E. MASSEY, DIRECTOR, NATIONAL SCIENCE FOUNDATION, AND DAVID T. KEARNS, DEPUTY SECRETARY, DEPARTMENT OF EDUCATION

Dr. **Massey**. Thank you very much, Mr. Chairman and Members of the subcommittee.

It's—I welcome the opportunity to testify before you today. In fact, when I learned that the National Science Foundation was being invited to testify on the topic of educational technology this morning, I asked to be allowed to appear personally because of the great importance that I place on this topic. I have prepared written testimony and I submitted that and I would like permission to have that inserted into the record, Mr. Chairman.

Mr. **Valentine**. Without objection.

Mr. **Massey**. Twenty years ago, computer-based instruction meant a student sitting in a cubicle, staring at a computer screen, and trying to answer the problems that came up. The computer would check the answer and let the student know how he or she was doing. The learning method was drill and rote memory, but with the computer simply simply replacing the blackboard or work book.

The difference between that activity and the educational technology available today is the difference between tic-tac-toe and Nintendo. In a classroom today it is possible to hook up to the computer networks that allow grade school students to communicate electronically with other students around the country or even around the world.

Kids Network, a widely used program developed with NSF funding, gets students involved in an acid rain project, for example. They gather data on acid rain from their own backyards, enter the data into computers and it goes by phone lines on the network to participating schools around the country.

Students then use this large data pool to plot graphs, develop sophisticated maps and formulate hypotheses about where acid rain comes from and how various areas of the country are affected by it.

These students are learning science by doing science. Their excitement and enthusiasm is immediately apparent. Getting these types of programs into schools has not been as rapid as most of us would have liked, unfortunately. But the National Science Foundation is supporting two large programs that should speed the availability of this type of technology to schools across the country. Let me just mention those briefly.

The first is the Statewide Systemic Initiative. Recently, the Foundation awarded $15 million in matching grants to 10 different States to look at different ways to restructure the entire State educational system.

Several of the winning proposals specifically focused on education and technology. Nebraska, for example, proposed establishing a computer network that would give rural schools computers—computer access to educational opportunities and experiences that are now only available to many students in some of the wealthier districts, as Ms. Horn pointed out.

The equitable distribution of this technology should be a national priority, and we are certainly making that a priority at the NSF.

The second way the Foundation is expanding its involvement in educational technology is through the Federal Coordinating Committee on Science Engineering and Technology, the FCCSET process.

NSF has joined with other Federal agencies to develop the National Research and Education Network—NREN—as the—as it is called. NREN will demonstrate the feasibility of connecting people with computers the same way we now connect people with telephones.

Let me give you an example of the difference between a voice telephone link and a computer link. Imagine calling the library and asking the librarian to read to you from an anatomy book the sections relevant to the heart and to describe the pictures contained in that book—that's one way to do it.

Compare that with hooking up your computer to the library's computer and electronically downloading an anatomy book into your computer in a matter of seconds. Given the right graphics you can now use your computer to search the text for all references to the heart and you might want to display a picture of the heart that then you can rotate to look at the various angles, sections, and to look inside and trace the blood flow or look at the flow of blood through arteries. This technology is now available.

NREN is often described as having the potential for putting any book in the Library of Congress at the disposal of every school in the country.

But more than just static words on computer screens will be available. This network envisions the capability for complex graphic presentations, entry active visualizations, and the technology for real time collaboration among teachers and scientists.

In fact, the area of visualization may be one of the most dramatic. And, Congressman Valentine, the NSF has just funded a Science and Technology Center at the University of North Carolina in connection with other schools that will be specializing in visualization.

And this weekend, I will also be privileged to speak at Super Quest, a recognition dinner at the North Carolina Supercomputer Center as part of the National Science Foundation's Advanced Scientific Computing activity.

Through this activity we support at supercomputer centers around the country ways to give high school students an opportunity for hands-on experience in working with super computers.

Teams of students and their teachers submit proposals to participate and to use time on the supercomputer, and they submit very sophisticated problems, I tell you, for high school students. A title of one, for example, quote, "A Mathematical Treatment of the Projectory of an Orbiting Body around a Nonsymmetric Body." That's one of the easier ones.

Super Quest is a valuable incentive for high school students, but we need to broaden our efforts to include even younger students. Current obstacles to doing this include a lack of access to computer networks, software that is difficult to learn and use and, unfortunately, a paucity of people who excel at teaching and also have computer skills.

Also, we lack the necessary curriculum and instructional methods, because these are not now designed to take maximum advantage of the technology.

At the Science Foundation we are expanding our existing programs to help meet these problems.

The business community is also becoming more involved, I'm sure as you will hear from Mr. Kearns this morning. For example, NSF is now supporting a networking project in Indiana where high school children can network with professionals from Eli Lilly for active consultation on science projects in which they are involved with in their schools.

And one of the most important contributions made by businesses is the time that the professional employees provide to serve as mentors, teachers, and collaborators using electronic networking.

Mr. Chairman, we can use technology to excite and captivate young minds but we cannot rely on technology alone to solve all of our problems in education, as Mr. Gilchrest rightly pointed out.

However, we must build on the progress we have made in applying computers and other information in communication advances to educating our youth.

I thank you for this opportunity to testify before you today and I look forward to working with your subcommittee and the full committee in the future as we learn how to use these technologies to our advantage.

Thank you very much.

[The prepared statement of Dr. Massey follows:]

TESTIMONY OF DR. WALTER E. MASSEY
DIRECTOR, NATIONAL SCIENCE FOUNDATION
BEFORE THE SUBCOMMITTEE ON
TECHNOLOGY AND COMPETITIVENESS
SCIENCE, SPACE, AND TECHNOLOGY COMMITTEE
U.S. HOUSE OF REPRESENTATIVES
JUNE 18, 1991

Mr. Chairman, members of the Subcommittee, thank you for this opportunity to testify before you today. When I learned that the National Science Foundation was being invited to testify on the topic of educational technology, I asked to be allowed to appear personally because of the great importance that I place on this topic. I have prepared written remarks and I would like permission have these inserted into the record.

We all recognize that trained, educated and scientifically literate people are the major resource of any modern society. In recent years, however, American students have performed poorly on international comparative exams in math and science, often ranking below nations with far fewer resources. By grade 5, U.S. students score about in the middle on international science tests. By grade 9, the score at the bottom.

No one is naive enough to believe that we can find a purely technological solution to our educational problems. Yet it is undeniable that changes in technology, fueled by advances in computers, hold great promise for improving our educational system. A failure to put this technology to use in educating our youth would be negligence at the highest level.

NSF'S SUPPORT OF RESEARCH IN EDUCATIONAL TECHNOLOGY

NSF has been a leader in exploring the potential of computers as educational tools for nearly 25 years. Beginning in 1968, in response to a Presidential directive, NSF established an Office of Computing Activities. While most of the work supported under this program was at universities, a portion supported computer assisted instruction at elementary and secondary schools. Within this program, NSF provided support for the development of LOGO, a computer language suitable for introducing children to computers as early as the second grade.

In addition to computers, NSF has been active in the development of other emerging educational technologies from their earliest stages. During the late 1960s and 1970s virtually every technology-based teaching tool and methodology had its origin at NSF, including computer networks, graphics, speech synthesis, programming languages, interactive video discs and computer literacy for educators.

We are major supporters of the seminal work in artificial intelligence that underlies intelligent computer tutoring systems. In the past decade, NSF has continued its support of basic research on technology for education by developing industry partnerships and interagency cooperative efforts. To stretch our limited resources, NSF successfully encouraged industry donations of computer equipment to schools.

The budget requested by the President for FY 92 provides substantial increases for NSF directorates for Education and Human Resources (EHR) and Computer and Information Science and Engineering (CISE). Within these activities, we have placed emphasis on research to accelerate the effective use of new technologies by teachers. Our Materials Development, Research and Informal Science Education program, where much of the education technology research is supported, has grown from $48 million in FY 90 to $82 million in the FY 92 request.

PUTTING EDUCATIONAL TECHNOLOGY IN PLACE

While we have made much progress in research on computer and related educational technology, bringing this technology to our schools has met with mixed results. Diffusion of technology into the elementary and secondary schools has not been as rapid as we would have preferred.

Two trends that are receiving high levels of support at NSF indicate that we may be on the verge of accelerating the use of technology for educational purposes. One is the recognition of the need for a comprehensive reform of the educational system at the state level, rather than piecemeal changes in individual schools or school districts. A second is the recognition that computer, information and communication technology can be integrated to bring their combined power within the reach of every school in the country.

The need for a top-down reform of state educational systems is reflected in NSF's Statewide Systemic Initiative, through which we recently awarded $15 million in matching grants to 10 states to look at different ways to restructure the entire state educational system. Several of the winning proposals specifically focused on educational technology. Nebraska, for instance, proposed establishing a computer network that would give rural schools computer access to educational opportunities and experiences now only available to students in urban areas.

The second way that NSF is expanding its involvement in educational technology is through the Federal Coordinating Committee on Science and Engineering Technology (FCCSET). NSF has joined with other Federal agencies to develop the National Research and Education Network (NREN). NREN will demonstrate the feasibility of connecting people with computers the same way we now connect people with telephones.

NREN has been described as having the potential of putting any book in the Library of Congress at the disposal of every school in the country. But more than just static words on computer screens, NREN envisions the capability for complex graphic presentations, interactive visualizations and the technology for real-time collaboration among teachers and researchers across the nation.

Since the late 1960s, NSF has played a lead role in improving and diffusing computer networks. NSFNET connects over 5,000 different networks in the U.S. and abroad. Our experience in this area has resulted in NSF being designated as the coordinator of interagency activities with respect to the development and deployment of the NREN.

As an example of how the business community can be involved in educational programs with computers, NSF has supported a project in Indiana where school children can network with professionals at Eli Lily for advice and consultation in their science projects. One of the most important contributions by businesses in education has been the contribution of talented employees to serve as mentors, teachers and collaborators through networking.

This weekend, I am privileged to speak at the Superquest recognition dinner at the North Carolina Supercomputer Center. As part of our Advanced Scientific Computing activity, we support such programs at supercomputer centers around the country to give high school students an opportunity for a hands-on experience using a supercomputer to do science. Teams of students and their teachers submit proposals to participate and the winners are invited to the center where they are trained to use the supercomputer to solve their problems.

This program is a valuable incentive for high school students, but we need both to broaden our efforts and move them to younger students. Current obstacles include a lack of access to computer networks, software that is difficult to learn and use, a paucity of people who excel at teaching and also have computer skills, and curriculum and instructional methods that are not designed to take advantage of such resources.

NSF plans to expand existing programs to help overcome these problems through both EHR and High Performance Computing and Communication intiatives.

Mr. Chairman, before becoming the Director of the National

Science Foundation, I have had the privilege of serving as a university dean and vice president, the director of a major federal laboratory, and on the boards of directors of a number of technology dependent companies. From these vantage points I have seen what can be done when committed people work together to solve difficult problems. Let me leave you with two statistics that point to how our future human resources requirements demand that we use every tool at our disposal in overcoming our educational problems.

- Of every 4,000 seventh graders in school today, only six will ultimately receive a Ph.D. in Science or Engineering -- of these six, only one will be a female.
- By the year 2000 minority students will account for 40% of our elementary and secondary school population. Yet only 4% of undergraduate science and engineering degrees are awarded to minorities.

We must use the technology that is available to us to excite and captivate these young minds. We are missing too many opportunities; we are wasting too much talent. As I said at the outset of my statement, we cannot rely on technology alone to solve all of our problems in education. We must, however, build on the progress we have made in applying computers and other information and communication advances to educating our youth.

I thank you for the opportunity to testify before you today. I look forward to working with your Subcommittee in any way that I can to move the highest quality educational technology into our schools.

Mr. **Valentine**. Thank you, Dr. Massey.

Mr. Kearns?

Mr. **Kearns**. Just to set the record straight, for those of you who referred to me as Doctor, I was referred recently in the newspaper article as Lou Gehrig, which certainly would have upset my baseball coaches. And my physics and math teachers would be horrified to think that I was now being referred to as a doctor.

I'm pleased to be here, Mr. Chairman, to represent the Department of Education. I got involved and interested in education because of the productivity issues in the United States, and a commission I served on in the early '80s. And my many travels to Japan in trying to figure out and work with Xerox people on how we were—were going to be able to compete.

And the more I got involved, the more I understood how important the fundamental underpinning was—was the issue of education and education of all our people.

But when Dennis Doyle and I wrote that book—and, Don, I appreciate your comment about the book, and Dennis Doyle particularly would because he gets royalties from it, I do not.

But we referred to in that book, and I'd like to—to talk about—we've always done quite well in the United States educating the top half. Our international competitors educate everyone and we must do exactly the same thing. And no one can be left out.

In fact, one of the fundamentals in the six goals is that everyone can learn, and everything else flows—flows from that. I believe strongly that technology can help a lot and may in fact be a—the major investment that we can make in the Nation to have a substantially more efficient system.

I'd like to, rather than repeat what I put in the official submission to your committee, Mr. Chairman, the different education technology programs that the Department of Education has, and those things are working very closely with NSF—and the other agencies. But I'd like to take just a moment to talk to you about two things.

First of all, an experience that Xerox had, an investment that the corporation made and; secondly, to talk about briefly America 2000 and how it fits from a technology standpoint.

Out of our Palo Alto research lab about six years ago, Xerox did the initial funding for the Institute and Research on Learning and it is hived off now as a nonprofit research laboratory.

And this came from the computer scientists at Palo Alto who were working on artificial intelligence and other advanced computing and—and programming systems. And they had looked at and concluded that—that fewer than a hundred computer scientists in the world were looking at the issue of how young people learn—not about putting a computer in the classroom, but utilizing technology to do basic research. And that laboratory has been set up with people—not just computer scientists, but educators, anthropologists, psychologists, to look at education in the total context to try and understand how young people learn, what they call "situated learning—learning environments."

They are using the process to get away from the black box, and the term they use is "glass box," to really understand what is taking place.

Mr. Lewis referred to the lack of use of technology in the classroom and we found, in preparing for this testimony, some words from the NAEP (National Assessment of Educational Progress) report that came out just two weeks ago—June 6th. It said, according to both students and teachers, about half the 4th graders never used calculators and about half the 8th graders never used computers. Two-thirds of the 12th graders, both overall and in mathematics classes, reported that they never used computers.

They concluded by saying, by more closely paralleling how mathematics is applied in business and industry, the use of technology in mathematics classrooms could facilitate substantial improvement in student achievement.

Let me move on to one particular facet of the AMERICA 2000 strategy, and that is the idea—that was referred to earlier this morning—of new American schools. We obviously have to work and fix and use technology in all the schools that we have currently. But while we are doing this, the idea of breaking the mold and not trying to figure out how we catch up to the Japanese, or catch up to the Germans, which is a concept that, frankly, offends me. There is no reason, I believe, that in this country we cannot describe and understand and invent schools that are uniquely American for our culture that are the best schools in the world, and that will, in fact, drive this Nation to be the best in the world and be able to compete with anyone, anywhere, at any time.

And this basic thought is that we would energize three to seven R&D teams of the best that we have in this country—from education, from industry, from think tanks—put them together and have them invent the schools for the next generation, thinking about the environment, the legislation that might be required at the local and State levels, to think about how we will interact with the most advanced technologies, and to make this research and development activity available to every community and every State across—across the Nation.

It is not a substitute for all the work that is currently going on, but it is clear that if we're going to be the best in the world, then we have to invest in technology and in new thought processes.

In an early school that I went to while working at IBM many years ago, late at night, talking to my roommate, who was a researcher, I was complaining about one of the current computers, and that it wasn't going fast enough, and the failure rates were too high. And he rolled over before he went to sleep, and said, David, you remind me of the farmer in 1850, when asked what he wanted, he said, I'd like a horse that is half as big, twice as strong, and eats half as many oats; but he never asked about a tractor.

And we really have to think very differently as we look to the next century, and I believe the application of technology is absolutely key.

A concluding comment is that Dr. Massey referred to FCCSET—Allen Bromley, the President's Science Adviser, has asked me to vice chair the Committee on Education and Human Resources with Luther Williams, who works for Walter. But in addition to that, chair a group to pull the six task forces of the CEHR Committee together, to ensure that education is working with NSF, Energy, the Labor Department, and across the Federal Agencies. Because I believe, as Dr. Massey said, if we pull the resources from all of the different agencies together, I think the opportunity to—to make major change and impact what's going on, particularly in math and science education, will give us a tremendous opportunity.

Thank you very much.

[The prepared statement of Mr. Kearns follows:]

DEPARTMENT OF EDUCATION

EDUCATIONAL TECHNOLOGY: COMPUTER BASED INSTRUCTION

Witness before the
House Subcommittee on
Technology and Competitiveness
June 18, 1991

David T. Kearns
Deputy Secretary

Mr. Chairman. It is an honor to represent the U.S. Department of Education before the Subcommittee on Technology and Competitiveness in one of my first official acts as Deputy Secretary. I am also flattered that you quoted me in the Charter for this hearing. The impact of deficiencies in the preparation of U.S. students has a direct and critical impact on American industry's ability to be competitive. The burden of remedial education that falls on industry, higher education, and others is a problem that must be eliminated.

As requested, I am going to briefly discuss some of the Department of Education's programs in Computer Based Instruction and other technologies. Then I would like to talk about the President's AMERICA 2000 plan as it relates to technology.

No one can doubt the potential of technology to play a central role in increasing the productivity of our schools. Realizing this potential is a prominent feature of the President's AMERICA 2000 plan. With the major changes in our schools envisioned in this plan, we must look for opportunities in computer based learning and other technologies.

But to take advantage of the potential of computers and other technologies, our fundamental concern must be with understanding how children learn. Research and development is needed on schools and learning, and how technology can support learning. I know of some of this type of research because of the work the Xerox Corporation supported through the Institute for Research on Learning in Palo Alto. Drawing on researchers from a number of disciplines, the Institute is pursuing the idea of "situated" learning, how individuals can learn much more effectively in a specific learning context. Xerox Corporation also supported research on technology at Bank Street College, which is also the location for the Department's Center for Technology in Education.

But much more needs to be done. According to Henry Becker, a prominent researcher in technology from Johns Hopkins University, computers will come to be more valuable in the schooling effort only if we ask our schools to make major changes in the activities and tasks given to students. Students must become active learners engaged in problem-solving related to complex, not artificially simple, questions. This is just part of what AMERICA 2000 proposes to do.

U.S. Department of Education Programs

The use of technology, and particularly the computer, has grown rapidly in our schools. The Office of Technology Assessment reported that the number of schools with computers grew from about 15,000 to 77,000 between 1981 and 1987, an average of 11% per year. It now is common to find computers in the classroom and a computer laboratory for the school. The use of video discs and electronic networks have shown substantial increases, as well.

Many examples exist of how to use technology in the classroom. The Department has a number of existing programs that aim to create top-quality applications and the proper conditions for using technology. Let me provide a few examples.

The Fund for Innovation in Education supports a variety of efforts to identify and disseminate promising approaches for improving schools. One component of the Fund, the computer based instruction program, supports projects for the purpose of expanding and strengthening computer based education in public and private elementary and secondary schools. One such project in Portland, Oregon aims to significantly increase the academic success of at-risk students by providing an innovative, highly individualized, technology supported, instructional delivery system.

Another program of the Fund for Innovation in Education is Technology Education, which supports the development of radio, television, telecommunications, and video based programs directed at improving teaching and instruction. Under this program, The National Science Teachers Association (NSTA) received an award to develop student assessments, based on performance, using interactive video discs. These assessments will provide authentic means of determining whether NSTA's national science reform project

- Scope, Sequence and Coordination - is able to significantly increase student science learning.

One of the Department's oldest, and most successful, technology programs develops technology, media, and materials for individuals with disabilities. This program currently funds interactive videodiscs and other computer assisted instructional technologies. One project developed video discs to teach mathematics and science concepts to young children. Another adapted a world history textbook to other media through computer based instruction. Through video and audio discs, it was possible for children to go back to other eras, to discover first-hand how families lived at that time, and to actually "talk" with people who lived in those settings.

As a means of expanding and enhancing educational access, the Star Schools program provides programming that would otherwise not be available to schools. The program supports telecommunications partnerships of schools, higher education, industry, and others to acquire facilities and equipment, develop and acquire instructional programming, and provide classroom instruction from central locations via satellite, hands-on microcomputer programs, and videodisc software. For example, the Massachusetts Corporation for Educational Telecommunications is developing materials on environmental science for grades 7 and 8 that call for students to collect data and then compare it with results collected by other students around the country via computers and satellites. 1600 schools in 40 States are now offering courses provided by Star Schools grant recipients.

Contributions by business firms are encouraged through our Small Business Innovation Research program. Firms develop designs and prototypes in Phase I of their project. Then the most promising are selected to develop their innovations in a second phase. Successful applicants have developed such products as voice synthesizer chips, visual displays of vocal movements that allow users to see how they pronounced a word, and devices to aid students with disabilities restricting their attendance in campus classrooms.

Another way in which the Department encourages the use of technology is through dissemination and technical assistance. The National Diffusion Network has at least 15 technology projects that are proven effective and are available for dissemination and replication. And the Regional Education Laboratories assist educators and policymakers in the use of technologies. For example, the North Central Lab developed a distance learning reading program for schools in rural Wisconsin that permits them to have the interaction among teachers by telecommunications that larger school districts can do on site.

The Department also supports the Educational Resources Information Center (ERIC), a nationwide information network that acquires, catalogues, and provides access to education literature. The ERIC database contains over 650,000 documents and articles on education-related topics. The ERIC system consists of 16 clearinghouses, a central processing reference facility, and ACCESS ERIC, a one-stop contact point for new users of the system. A clearinghouse located at Syracuse University specifically focuses on educational technology and library/information science.

Finally, there are many research projects being carried out by our National R&D Centers. The Center for Technology in Education at Bank Street in New York City that I mentioned earlier is focusing on technology and its integration into instructional environments. The role of technology in assessment systems, teaching, and learning-teaching-technology configurations are part of this research activity.

Significant research is also being carried out at other Centers. The Center for the Study of Learning at the University of Pittsburgh is developing computer based laboratories for teaching topics in physics, electronics, and economics. And the Center for Learning to Teach at Michigan State University has developed video discs for demonstrating to teachers how to teach mathematics concepts for understanding.

AMERICA 2000

Despite these and other promising examples, it is fair to say that the impact of technologies in the schools has been far less than hoped. Simply providing computers has had little effect because schools are not organized to apply them effectively. Nor are teachers prepared to use them as an integral part of the whole instructional program. We must make a break from the past, to take a fresh look at learning. This is what AMERICA 2000 proposes to do.

In the AMERICA 2000 strategy, the President proposes to create a new generation of American schools. To help communities create these schools, R&D teams will be established. These teams will aid in creating schools that are not bound by traditional assumptions about schooling; they truly will be breaking the mold of schools as we now know them.

Although new uses of technology are not a requirement of the new American schools, we would certainly expect that some of the innovations tried by the R&D teams would involve state-of-the-art technology applications. For example, computer based learning software now permits students to play an active role in creating learning. No longer need the program developer be in total control of the way learning is approached.

Interactive video discs also can allow students to play a more active role in their learning. Vivid learning situations can be created that permit, even require, students to select the path of learning and to continuously interact with the materials. Technology will not, of course, substitute for effective teaching. But it could provide tremendous help to teachers in tailoring instruction to the needs and talents of individual students.

Technology will also be prominent in bringing America on-line, a means of networking the new American schools electronically. America on-line will provide students and teachers access to data bases for research and instruction, create mentorships, and permit an exchange of information on teaching and learning that is now impossible.

But AMERICA 2000 does not speak only to the new generation of American schools. Better and more accountable schools for today's students are essential to the strategy. With the development of World Class Standards and American Achievement Tests to measure student achievement, computers and other technologies may well be a means of creating realistic assessment tasks. Further, in the Governor's Academies for Teachers and School Leaders, technology might be an important part of the content of the curriculum, as well as a means of delivering it.

These are only a few of the possibilities for using technology in AMERICA 2000. I am sure that the ingenuity of the R&D teams, schools, researchers, and many others will lead to many more. Collaboration and coordination with other Federal agencies, such as NSF, will enhance these efforts. The Department of Education has already collaborated substantially with these agencies through the Committee on Education and Human Resources of the Federal Coordinating Council for Science, Engineering, and Technology. Further, NSF and other agencies have generously contributed their time to participate with our internal Steering Committee on Mathematics and Science Education. We expect these mutual efforts to continue and to grow.

Thank you. I will be glad to answer any questions you may have.

Mr. Swett. [presiding] Thank you very much, Mr. Kearns.

I would like to start out the question and answer period with a simple examination of the cost effectiveness of this program that you have outlined—the education 2000 program.

It seems to me that a great emphasis here is being placed on technology—that's why we're meeting this morning. I understand that in the focus of this subcommittee hearing, we want to attach ourselves to that technological advancement.

I also think that there are critical questions to be answered regarding interaction of teacher/student in technology, that there are aspects of the teacher interaction that are equally important.

But before I get into that I would like to ask you a question: Are there other ways to achieve similar results without the large start-up costs that I perceive this kind of a program is going to incur?

Mr. Kearns. Mr. Chairman, I think we have to think of this in—in really two tracks. The first track of the program is a whole set of things of improving our current schools. And I think there are a lot of things, as you suggest, that can be done, some without much cost at all.

The idea of a new generation of American—of American schools is not a very costly effort if you think about it; and I think it may lead—don't know for sure—to major advances.

But if we spend about $200 million on these R&D teams, that is a very, very small amount of money. We spend someplace in the area of 200-250 billion dollars a year in education in the United States, and that excludes about $200 billion that industry spends on training their people.

So I believe that there—that we must do the R&D work, but there are lots of other things that can be done. Teacher education is extraordinarily important. There is an effort under way that was started by Dr. Leon Letterman, Nobel Prize physicist from the Fermi Laboratory, supported by the Energy Department and the business community in Chicago, that has started an academy to teach the elementary school teachers how to teach math and science. It's a marvelous effort and it has brought together foundations, business, and the government in this program; and it is not costing the schools any amount of money.

In fact, this effort to get it going is the—the academy is, in fact, paying for the substitute teachers while the elementary school teachers are at—are being trained.

So there's a set of things, I think, going—going on that can be done where a lot of money need not—need not be invested.

On the other hand, for us to exclude investing in research and development, and I think the fundamental underpinning of our Nation education, I think, would be a crime not to do that.

Mr. Swett. Beyond these R&D teams that you speak of, we have tremendous hardware expenses to be incurred. Is this to be established in the schools through the marriage of business and education, that this hardware be provided by business; or how do you see that coming forth?

Mr. Kearns. Well, first of all, business can—businesses around the country can—can help in this, and they have. I learned last week IBM was in—going over their programs around the Nation, and they have a program where if their employees will put up 20 percent—in other words, this is to get ownership from their own employees around the Nation—then the corporation will put the additional monies in; or a group of employees could work with a—a school. And there's many other companies that—that have programs that can be of assistance.

But if you talk—if you look at the total education bill in the United States, there is no question we need some upfront investment. But we need to be much more efficient. And I believe that in the longer term that we—this should be in fact paid for out of the tax base. We must need a strong public education system in this country. And in fact, if business decided to pay—to pay for it, I don't think the American public would put up with it. Because I think we should have a strong public system.

And while I do believe there's some upfront costs involved, I think over the longer—the longer term—that the amount of money that we're currently spending on a per student basis and on a per capita basis or on a percent of GNP is probably about right; but we need to do it substantially more efficiently.

And the last point I'd make on this is that I would urge everyone, in every community, to make sure that the dollars that are being spent are being spent on the schoolhouse where the children and the teachers are. And I think that's absolutely imperative; and particularly when you look at the larger school systems, there's an awful lot of money that is spent outside of the school—of the schoolhouse where the youngsters and the teachers are.

Mr. SWETT. Dr. Massey, what role will the NSF play in the model school program with one model school in each congressional district?

Dr. MASSEY. I see several roles where our Statewide programs would fit in perfectly; and, of course, will be coordinated through the FCCSET programs.

Let me just, for example, go back to the Statewide initiative that I mentioned that we are now funding in a number of States.

This is an initiative to bring together all of the resources in a state that have to be—work together to improve the quality of education—the school system, the universities, private industry, and the like.

One could easily imagine as part of that initiative in a State that they could fold into that one of these experimental schools that could provide a test bed for many of the technologies, the training methods, and the—and so forth, that are being supported by NSF programs.

One of the greatest barriers to utilization of the technology that we have now is the inability of the—many teachers to effectively use the technology.

So one of the other things that might be done in these schools is to combine them with teacher enhancement programs now supported by the NSF to train the teachers to use effectively these new technologies and others.

So the president's AMERICA 2000, and especially the experimental schools programs, is a natural fit with many of the programs already now supported by the Foundation. And the two together would provide a synergy that goes beyond the simply bringing the amount of money together supported by—that support both.

Mr. Swett. As we talk about going beyond the program as has been put forward by the President and the Administration, has there been consideration to utilization of telecommunications to access these magnet schools, or these individual schools, you know, these model schools in each of the districts so that the programs that they're able to develop might be put into other non-participating schools in such a way that there is at least a residual or an aura that impacts the entire district?

Dr. Massey. Of course, that's exactly what is intended. And the key to that will be providing the effective networks that can be used to transmit data at a rate that makes it effective.

This NREN network that I mentioned in my testimony, when completed, will be the infrastructure for allowing that to happen. That's already happening in some cases now through the NSFNET, the National Science Foundation Network.

Mr. Swett. To what percentage?

Dr. Massey. I don't know to what percentage of schools around the country that would be connected to that. I can find out. It's mostly in particular regions, though, or through networks across areas.

One that will provide a model for that is the one in Nebraska that I also mentioned, and where the state's program is focused on just the model you elucidated, providing a network that will allow the schools in areas that have resources and things—equipment in the classroom, to connect with schools that are in the outlying areas of Nebraska that don't have those resources without duplicating everything around the State in every school.

So the model you outlined is just the type thing we're working towards.

Mr. Swett. I would be interested in learning more about that.

I have been advised by staff that we will try and adhere to our 5-minute rule with—with hopeful consistent regularity.

At this time I'd like to turn the—the microphone over to my distinguished colleague from Pennsylvania, Congressman Ritter.

Mr. Ritter. Thanks, Mr. Chairman.

Just touching on this school of tomorrow a little bit more. Mr. Kearns, you certainly have had the range of experience in business and there's a lot of American business that is getting more and more interested in the suppliers of their workers and the schools that those workers seek.

How do you envision the role of business? I mean, could you take—could you kind of take us through some steps as to how the business community is going to play a role with the education community?

Mr. Kearns. I believe it's a—it's broad role. I would start by saying that my response to business people across the country, they say, what can I do right now?

And I say, support the educators and the politicians that are calling for systemic change, and will change.

The second, a Business Roundtable organization that I have been—been involved in, is a strategy to divide up the States between the major companies to work with the governors and at local levels, and major systemic change, including legislative change, so that it might be required both at the local level and at the—at the State level.

We are hopeful and the—the original—the initial signs are—are encouraging, that the American business community will support this nonprofit corporation to raise the money—150 to 200 million—million dollars—to get these R&D efforts under way.

That corporation is being supported by the Business Roundtable, the U.S. Chamber of Commerce, the National Federation of Independent Business, the American Business Council, and pulling the entire business community together. I've spent some amount of time over the last two weeks working with the Chamber. Jeff Joseph is here this morning, working with him and his colleagues; working with Ed Donnelly, one of your constituents from Air Products; with the National Alliance for Business, and these other organizations that I—that I mentioned.

I believe that the key role that businesses will have will, while working at the State level, the key role will be in fact in the local communities. That's where their employees are and that's where they can work the most—the most closely with, and help with systemic change.

It's extraordinarily important that the businesses and the interactions they have are for systemic change and not programs which, Ted Foliere at the University of Minnesota, likes to call "feel good partnerships," that in fact don't do much, but shore up an old system.

But businesses have a major role to play in an area that you are interested in, in quality, for example. The Xerox Corporation, my former company, has three people on loan to the Rochester, New York school system, working the quality process with—with them. And while that's not direct money, that's bringing expertise from employees, but it is also bringing an ownership in the—in the community of working with the-with the Teachers Union. The Rochester Teachers Union up there, led by Adam Urbanski, has been a major player in this as well as Peter McWalters, the Superintendent of Schools, and—and other businesses.

So it's a broad—it's a broad range, and it needs to be driven at the local level.

Mr. RITTER. It's interesting you mentioned money. The investment in education per capita percentage of GNP invested in education in America is the highest in the world, I think save for Sweden. There are some different breakdowns—that we spend more at the higher education level than we do at primary and secondary, in terms of the breakdown. But we are up there at the very, very top in expenditures in education, and the system is not working in spite of the money that we spend.

Who coordinates these series of—is there a coordinative role? Is everybody out there on their own? Is that the Department of Education's role? Are you still working that up?

I mean, you know, we've had a lot of Federal programs where the funds go flying out in different directions, a lot of centrifugal force, and nobody ever really figures out what happened to them, and except that they were spent.

How do you synergize these processes so that the whole is a lot greater than the sum of the parts and that the rather small amounts that actually—of the money that does get spent—the small amount of effort that does get expended is somehow nurtured and grown?

Mr. **Kearns**. First I'd like to mention, and come up what Dr. Massey said before, that the FCCSET effort is a very important effort to take all of the parts of government, because, as you stated, the—the direct education process in this country, about 92-1/2 percent, are spent at the state and the local level.

So I—it's important that Health and Human Services that has responsibility, for example, on Head Start—Dr. Massey talked about a series of things that NSF has in the Labor Department, that these be coordinated, and that's the purpose of—of FCCSET, and that—and that's being done from a Federal coordinating viewpoint.

Mr. **Ritter**. That will integrate with the President's education 2000—

Mr. **Kearns**. Yes.

Mr. **Ritter**. —goals and program and school of the future?

Mr. **Kearns**. The answer on the—on the new generation of American—of American schools, that will be a—a nonprofit, private organization that will—that will let the R&D contracts; those contractors will take advantage, as Dr. Massey suggested, of a whole set of work that is already going on out there, including experimental schools to bring in; and I would hope that some of the activities, for example, that are—that are taking place in some cities will become part of the R&D as well as work that is already—that is already under way.

It is our hope that legislation could be passed in the—in the Congress that would give the idea of a million dollars for each congressional district to jump-start to get these—get these—to get these programs going across the Nation. But our hope would be that that R&D effort would be available to every community that businesses, foundations, and local governments would fund way beyond the 535—that that was a way to get this going.

But the overall AMERICA 2000 strategy is an attempt to have a coordinated strategy across more and better accountable schools, track one, a new generation of American schools, which is only part of it.

And, third, a very important part of it is improving the skills of the work force that is already out there, and to work with the States and the local communities in—in a coordinated effort during—during the '90s.

And I believe that the—this is a role that is appropriate for the Federal—for the Federal Government in what has been, and I believe should continue, a limited role; and the local governments and States will have the continuing control over their education systems, which I believe is appropriate.

Mr. **Ritter**. Thank you.

Thank you, Mr. Chairman.

Mr. **Swett**. Thank you.

We'll now hear from my distinguished colleague from Missouri, Congresswoman Kelly Horn.

Ms. **Horn**. Thank you, Mr. Swett.

The first comment I'd like to make to Mr. Kearns is something I became very well aware of just over this past weekend when I was back in St. Louis, and I hope that you are taking this into consideration all over this country. In the St. Louis area we have had for many years cooperative efforts between the schools and businesses, some with more success than others, and they have on their own stepped back a year or so ago and put together a partnership that's more formalized—looking at what's worked and what's not worked.

And now all of a sudden from on high, we are having incredible competition for funds, because the folks from Washington are saying, hey, wait a minute, businesses, here's the program that you're to donate to now, this is the cause of the year, these schools in every district. And that is going to be a problem unless done with great sensitivity.

I don't know what the number would be but I would submit that there are probably not a great number of the 435 congressional districts in which these efforts are not under way.

But in those in which they are not only under way, but are being evaluated, being done well, being done with care, about what the local needs are, I would submit that efforts from on high that to say to those corporations, we want your money for this purpose, which totally takes that money out of what's being done on the local level, I would urge sensitivity to that, and ask, perhaps, if you might be aware of that consideration.

Mr. KEARNS. Ms. Horn, I agree about the sensitivity issue, and—but not your on high comment.

We want to coordinate this very closely with the efforts that are going on. I've spent a good part of my time over the last four or five weeks doing this. I spent—was in Chicago, I mentioned earlier, and the purpose of that visit was to visit specific schools. Efforts the business community had to work with the civic organization that they have pulled together to ensure that these are coordinated the similar reason to meet with the Chamber; and sensitivity does—is called—is called for, and I believe that the—the group is—is working this very carefully.

The—a group of business people from around the Nation representing the U.S. Chamber, American Business Council, the Business Roundtable, the National Federation of Independence—the Independent Businessmen—was put together. And these—this effort of the track 2 new generation of American schools was in fact closely coordinated with the Business Roundtable and these organizations before we went forward.

But we do have to be cautious. We do not want to drain dollars off of—of the-the efforts that are under way. And one of the reasons that we went to the broadest business community was not just to go back to the largest companies in—in the country, but to—to broaden this—broaden this effort.

And if you think about it on a national basis, 150 to 200 million dollars to be put into this project over three years, in fact, gives the business community an opportunity for a direct hook to something that for the next century could make a tremendous difference.

But I do agree with your point about sensitivity, and we will work that very carefully.

Ms. HORN. Thank you. I appreciate that, because, as I said, I'm sure in some areas it's not of import, but in others it definitely would be.

I also hope that when you're dealing with the business community—and I don't become necessarily critical when I say this, and I understand the reasons behind it—but the dollars that the business communities are putting into education now do not even begin to equal the dollars they have taken out of the educational system by tax abatement over the years.

We have a major corporation in downtown St. Louis which puts about $50,000, $100,000 into educational programs, but they, because of tax abatement, withdraw, keep from the local schools more than a million dollars a year in taxes. And this happens all over this country. There are many reasons for those tax abatements being given: competition, which I deeply regret, amongst the regions, and cities, and States to get certain businesses to locate there—and that's the way it is.

But I also want to make sure we don't get too caught up in thinking of this as charity.

Also, as someone who has spent many years in the classroom, all the way from preschool education to teaching college students, I spent an incredible interesting day yesterday at a major research university in our city, dealing with the mapping of the human genome, and that was a wonderful enlightening experience.

I hear you talking, though, about R&D on how children learn. And I don't think that's any big secret. Now if you're talking about which chromosome holds which genes that deal with which thing there, in mapping the genome they have got part of the x/chromosome that will represent about 4 percent of the total mapping, and it takes up a wall about that size. It is absolutely a fascinating undertaking, and we do have lots to learn about how the brain works in all of us.

On the other hand, we've known for a long time that children learn by doing. And if they're doing in an enriched environment, they're learning best of all; and in an interactive environment, I think Mr. Gilchrest talked about some of these things, too.

So there really is no great mystery there. We have somehow robbed our children of that ability to interact with their environment in what we do in some of our schools, and we need to get back to that.

But I'm wondering at what level you're relying on R&D to get us on with the business of what we really know needs to be done right now.

Mr. KEARNS. Well, let me—I'm not going to get into a debate with you, but I would like to say again, that there's a parallel track that we have to do this. And if you go to the six education goals that have been agreed upon, you—you do start with some things that we know.

But the number one goal is that all children should be ready to go to school by the time they're five years old. And I don't even like to talk about K through 12 anymore; I like to think about education as prenatal through 18—18 years old.

And there are things that we know. We know that kids don't drop out of school if someone cares. And there's a lot of things that are going—that are going on; and I agree with that.

And there is a lot that we know about learning. But not to—to utilize the technologies that have been developed since World War II, and to get our brightest people in this Nation thinking about the process of—the process of learning and how that—and how that works, to me, is not forward thinking. And we want to make sure that—that we have the very best schools in the world.

And I'm going to keep pounding away at that because we have to work all these things in—in parallel. And we have the resources in this Nation to do that.

Ms. HORN. Well, I agree, and stated that way, I certainly agree with you, Mr. Kearns. We absolutely need to use the brightest and the best and technology in every other way.

I have no other questions now. Thank you, Mr. Chairman.

Mr. SWETT. Thank you, Congresswoman Horn.

We'll now hear from our colleague from Maryland, Congresswoman Morella.

Mrs. MORELLA. Thanks, Mr. Chairman.

I'm curious about something called the Education Satellite. I have been meeting with sort of an advisory group who have been discussing how to get businesses and the private sector involved, a linking up with our National Science Foundation and certainly the Department of Education.

What do you think about that?

Can you see a future in it, or do you think it is a dream that is not approachable or not desirable—an educational satellite so that you could get things throughout the country—educational items, particularly in schools that might not have the kind of enrichment that has been discussed today that some of us may have in our communities?

Are you familiar with it?

Secondly, I wonder what your opinion would be of it.

You seem very interested, Dr. Massey, let's hear from you first on that.

Mr. MASSEY. Well, yes, I—I may not be familiar with the particular effort you—of which you're speaking, but the idea of using satellites to link different institutions is, of course, what's happening right now in many schools around the country. And there's a program that now links of students all over the country to study Japanese, for example—maybe this is one. But a student in Nebraska can communicate with a Japanese teacher in Tennessee, a native-speaking teacher, to—once or twice a week, may be of this network to have on-line interactive conversations, for example.

Satellites alone won't be the answer, but they will be part of this entire networking system. That's just one of the technologies that will be used to transmit over the air type communications—fiber optic cables may be more efficient in areas.

So the idea of linking is the key idea, independent of which particular technology you might use. And that's an excellent idea and it is, in fact, one of the things that is taking place now, as I stated, as part of this NSFNET that already has a number of schools aligned to it.

What one would hope to see in the future is a network—this National Research and Educational Network—utilizing the most advanced technologies, whatever they might be at that time, to link every school in the country; and that's not an unrealistic idea.

Mrs. **MORELLA**. Mr. Kearns?

Mr. **KEARNS**. I would just add—support that—just—we need to have as much information accessible to all the schools as fast—as fast we can. Only half the high schools in the United States have a physics teacher.

Mrs. **MORELLA**. Right.

Mr. **KEARNS**. So if you think of the technologies, the types of things that Dr. Massey was talking about, this speeding up the availability of this knowledge to students in—in schools will—as, again, the use of technology to have a more efficient system while we are getting more math and science teachers, which we badly—which we badly need.

Mrs. **MORELLA**. How do we do this? Where does it come together? I know we all agree on this.

Mr. **KEARNS**. Well, there are a number of efforts. Dr. Massey was—was talking about that, that the NSF is under. There's a star system that the Education Department is working with in conjunction with NSF, again, to get these—to get these networks up and running. And that will—that will continue—that will continue. And part of the—of the—of the AMERICA 2000 strategy have talked about this as America—American schools on line, bringing them all together. And the President has asked that the different agencies such as NSF and our own at Education that we coordinate that activity to—to come up with an overall—an overall—

Mrs. **MORELLA**. Are you familiar with the group that I alluded to—

Mr. **KEARNS**. No, ma'am.

Mrs. **MORELLA**. —called EdSat?

May I in the near future have somebody contact both of you to give you some—

Mr. **KEARNS**. Sure.

Mrs. **MORELLA**. —familiarization with it?

Mr. **KEARNS**. Yes, ma'am.

Mrs. **MORELLA**. It just may have some potential because it is bringing in some key people from the private sector to work on this concept.

Dr. **MASSEY**. May I just point out—

Mrs. **MORELLA**. Yes.

Dr. **MASSEY**. —in answer to your question, is where is the planning taking place?

Mrs. **MORELLA**. Yes.

DMr. **MASSEY**. These two documents that came out of the FCCSET process, brochure 1 on High Performance Computing and Communications, and the other is on the Education and Human Resources, lay out a strategy for developing this network that involves all of the federal agencies. So the plans are—

Mrs. **MORELLA**. Excellent, excellent, very good. I just think it's all very exciting.

The other day the Clearinghouse—the Congressional Clearinghouse for the Future—had an interesting multimedia program where they used laser discs to show what could be done in classrooms.

One that was done by the former producer of Nightline was on your Government in Action, and used some kids, in fact, and some from the school in my district, on the Supreme Court, and Legislative Branch and the Executive Branch.

The other functionary was IBM had done something on TIROS. They used as their theme Tennyson's Ulysses, and it was amazing how you could find out from that like what a tragic hero is throughout time, what the contemporary hero would be like.

It's so fascinating and I would imagine that this kind of multimedia, as part of the technology, would have a place in the classroom.

And then I get back to my original point in my opening statement about let us never forget the human dimension of the teacher/student relationship. I feel very strongly about that, as the real inspiration—all the knowledge is there in terms of by training teachers to make sure that they realize they must touch that student.

Would you like to comment on that?

Dr. MASSEY. I agree.

Mr. KEARNS. I agree too, and I would just say that that's—that was one of the major thoughts that this Institute for Research and Learning, which, by the way, NSF is—has supported—is to have anthropologists and psychologists and educators working in this to ensure the human dimension.

Mrs. MORELLA. Great. Thank you.

Thank you, Mr. Chairman. Thank you, gentlemen.

Mr. SWETT. Thank you very much.

I realize that I had reverted to social convention and protocol and not to Chairman Valentine's congressional protocol. I—I apologize, gentlemen. I will now turn the microphone over to my colleague from Maryland, Congressman Gilchrest.

Mr. GILCHREST. Thank you, Mr. Chairman, that's perfectly all right. I was brought up to always say ladies first.

Mrs. MORELLA. I thought you were going to say your elders.

Mr. GILCHREST. Oh.

[Laughter]

Mr. GILCHREST. That, too, Connie—but ladies.

Mr. Kearns, earlier you spoke about local communities more or less knowing the best way to create what's necessary for a viable educational system in their own backyard.

And I would like to say that I can't agree with you more. I think that's where education has to spring forth and the creator of imagination of each community across this country can, I think, in the long run, do the best job.

Keeping that in mind, and understanding that, this initiative is more or less coming from the Federal Government. Can you describe for us—and this is kind of in a generic way because it will be different from community to community—your idea for a school of tomorrow using computers?

And if you could, could you describe for us, let's say, a typical classroom of math or history in elementary or secondary, how these computers would work to enhance the quality of education?

Mr. **Kearns**. Mr. Gilchrest, I really can't—I can't do that. And I think each of us have our own ideas. And one of the thoughts, by the way, on the RFP for these R&D contracts, is not to try and proscribe the outcome by the way we write the RFP. In other words, to get the very best minds to think outside of the envelope in a different way.

I have spent quite a lot of time at this Institute for Research and Learning out on the West Coast and there are a lot of different—different ideas and thoughts about—about teaching—about teaching different—different subjects.

First of all, you started out by talking about the classroom of tomorrow. I'm not sure that we're going to have classrooms in the sense that we have them today. I don't know that. They could be very different. People might not do all of their learning in a school.

We certainly know some things, as Ms. Horn said before, we're the only industrialized nation in the world that stops for three months. Every educator will tell you that having kids stop for school for more than a month at a time makes absolutely no sense whatsoever.

Now, that's a different issue than whether you go from 180 to 240 days. It's—it's when you do it and what kind of—kind of chunks.

We're really quite sure that schools ought to start early in the morning and end late in the day, but that doesn't mean that the kids will be learning all that time, but it means that they are available for children to come early, go to school, and stay if necessary.

We also know in schools that are around the country today that look like they're working very well that teen-age mothers are also going to school in those schools to learn how to be parents. We know that day care—that probably development goes with day care.

So for me it's very difficult to describe the classroom—the classroom of tomorrow, or the school—or the school of tomorrow—but we have to get the best minds thinking—thinking about how that would be.

If you think about the technology that Mrs. Morella just spoke about, about satellites and communications being available to schools, why would it just be available in schools? Why wouldn't it be available in every home that has a television set—a high definition television set with a very low—low-cost printer, that could take off in color that which was on the screen? There are all kinds of technologies in—and uses for the future.

So—one, I'm not an expert in this—in this area and; two, I think we—that we don't want to describe it too precisely, but we sure should think about it so that we can answer your question as it applies community by community, to support the uniqueness of the communities across this country.

And that's why when we talk about and that's why I guess I took a little offense at Ms. Horn when she said coming from "on high", well, we're suggesting is this research and development be made available to every community so that they can apply it, use the R&D teams if they chose or not, but to apply it to their communities and how it—and how it fits. Because I don't think the schools in every community in this country should be the same.

I think the idea of a model school, cookie cutter approach to them, is a bad idea.

Mr. **Gilchrest**. Well, thank you, I think that's an excellent answer.

I'd like to say that I agree with you a hundred percent because there are certain communities where the school year should be 250 days and in some communities 180 days might be more appropriate.

For example, I have a son that works on a dairy farm in the summer. And he goes to school a 180 days out of the year, and in the summertime he works on a dairy farm, and he assists with the birth of calves; he helps out the veterinarian when he comes by, and he's learning a great deal. I'm not sure if I would want to take that away from him unless the classroom was as good as real life.

But perhaps that connection with that farm and the school, and the home, and the dairy industry, can be interconnected with computer technology.

Mr. **Kearns**. Why not?

Mr. **Gilchrest**. So it's an extraordinary thing. So I guess the only limits on our potential are our imagination and our determination.

Before I ask one more question I would like to introduce the children from—and the young adults—from Calvert County, and I'm looking forward to them showing me a little bit more about computers than turning them on today—that's about as far as I've gotten with computers.

Mr. **Kearns**. They probably know a lot more than all of us.

Mr. **Gilchrest**. I also will ask them a question that they can answer later if they want school throughout the summer.

[Laughter]

Mr. **Gilchrest**. Those are the experts on that.

I see some heads shaking both ways.

Mr. **Kearns**. Trapped, as usual.

Mr. **Gilchrest**. Perhaps. But maybe with the new ideas we can bring forth some different things.

I would like to ask Dr. Massey and Mr. Kearns, whichever would like to answer this question: You're talking about schools of tomorrow, and a tremendous amount of change, and maybe no classrooms, and maybe not that rigid schedule of first period, second period, third period, all the way through, five days out of the week.

When you bring those thoughts out in the open, and you're talking about computer technology, would some people recoil from because they say you can't replace the teacher—when these things are presented to the general public, if there is resistance from any particular group for these ideas, what group presents the most resistance to these new ideas?

Dr. **Massey**. Do you want to answer that?

Mr. **Kearns**. Thank you, sir.

Dr. **Massey**. You're welcome.

Mr. **Kearns**. I'll tell you where I think the most resistance comes—comes from, and I think this is a leadership issue. This committee is studying this issue, they're having hearings, and that helps; the President is talking about this, the business leaders are, the politicians are talking about this.

The polls still show that someplace around 14 to 15 percent of the population in this country thinks we have a problem. That's where the resistance is. And I think that is a leadership issue for all of us to convince, through proper communication and understanding that we have an educational issue in this country.

But with only 14 to 15 percent of the people thinking this is an issue, we're going to have a heck of a time getting the changes required at the—at the local—at the local level.

So that's where I believe the resistance is. And I think we all have—have a job to communicate properly, not to scare people into doing things, but to—to convince people that there's an issue. And then how can they participate and take—and take ownership.

Change is threatening to everyone. I like to say is there's no institution that I know of changes from the inside out; it changes from outside pressure. We never would have done the things that Don Ritter referred to at—at Xerox if we hadn't been literally threatened with going out of business. I thought when I took over as C—CEO in 1982 there was a good chance that Xerox would not exist in 1990.

Now, that gets your juices going. And you get forced to change. And the reason people don't like to make changes is that changes are—are onerous and they are to people and institutions that you care and love for. And, therefore, the communication vehicle of working, particularly when you get into technology areas for people, is to get ownership at a local level, and that means all of us, as leaders, have a tremendous communications job to do.

Dr. **Massey**. I wouldn't single out any one group as being more of an obstacle, but I would just follow up on the general principle outlined by Mr. Kearns.

I think the way we present the—these new technologies or programs will make a great deal of difference. The most important people in this whole enterprise, perhaps other than parents, I believe is teachers. We are not going to replace a generation of teachers overnight who are presently in the schools. And the schools are the—the locus of our activities now. So we are focusing on working with teachers. And, by and large, people want to do their job as best they can if you show them that you're trying to give them a better way to do their job.

And, again, to follow on your remark about working at the local level, getting the teachers involved in the programs, getting them to be partners and accepting it, I think, is the—is the best approach.

There will be some obstacles, there will be reluctance to change, for all the reasons that Mr. Kearns pointed out, but I think if we approach it the right way, we—we may be able to work around some of those problems.

Mr. **Kearns**. One of my associates slipped me a note—only 25 to 30 percent of the adults have children in school. So the issue is close working with the broad base. And we also have to think about that if you think about the work force and increasing the skills of the work force, 80 percent of the work force for the year 2000 is already out there. So part of what we have to do is increase the skills of our adults as well. And we need to make sure that when we're talking about education change in this country, that we—that we talk about better and more accountable schools than we have today, a new generation of American schools. And, third, increasing all the skills of all the people in the——in the—in the Nation. And that's a—is a difficult task. But, again, it's a leadership issue of—of convincing broad organizations that—that changing the structure of education in the United States is in the best interest of everyone.

Mr. **Gilchrest**. A difficult task but one of those worthwhile things that we can do for the next generation.

But I think working with the teachers and showing them that that they can do it, and it can be done, is—and the community and the business, is a worthwhile adventure.

Dr. Massey, Mr. Kearns, thank you very much.

Mr. **Kearns**. Thank you.

Mr. **Gilchrest**. Thank you, Mr. Chairman.

Mr. **Swett**. Thank you, Mr. Gilchrest.

The Chair recognizes you as our educational expert on the panel and, therefore, extended your 5 minutes to appropriately reflect your position.

We will now hear from our distinguished colleague from California, Mr. Rohrabacher.

Mr. **Rohrabacher**. I always thought summer vacation was a magic time and I would never try to eliminate that for any of these young people.

And it won't get me any votes from their parents, but—

Let me just suggest that much of what I've heard here today does indicate the potential that technology has for making us more competitive, and we talked about what computers and the future might do in the home in terms of education.

For some reason I have a feeling that there are a lot of homes that that doesn't apply to; and it may apply more to upper middle income homes than it does to homes that are just—people who are just struggling to pay their rent and they don't live very well.

I've just one question for both of our witnesses, and that is, can technology and education be used to help eliminate illiteracy from our society? And if so, how?

Dr. **Massey**. I don't—it can be used, certainly. And the way it can be used is by providing access to the tools that are need to educate people in places where there are now inaccessible.

You mentioned the fact that the new technologies might only be available to middle class homes. That probably will be true, just as everything is in the beginning. But if you look at the number of homes that have televisions and telephones, especially televisions, you will not find those only situated in middle class homes.

And the technologies that we are speaking of ought to be, or will be, as ubiqutous as—as the television set, or a telephone. So I don't think we'll be limited by the technology.

What we will be limited by are the uses to which it is put, and which brings us back to the question of how do we use the technologies to help eliminate illiteracy or other—or other—the problems we have with education. And it will come about if we have the kind of teachers in the schools that can link in with the networks where children are, and the participation of parents, which is going to be even more important.

One of the things that the use of technologies will be able to do is to perhaps extend the classroom from beyond a physical setting so that it might make it easier to link in families in the learning process than it is now.

But I don't have the answer to that, but one can certainly envisage various models which, if effectively applied, could address that issue.

Mr. KEARNS. I don't have much to add but I see it exactly the way Walter does, is that the technology will help us reach a—a much broader—broader base. And I think television—we've got to be smart enough in this Nation to use television in the positive rather than the negative sense.

We all know now that our young people, probably our adults too, watch too much television. But if we could think of that technology as a vehicle to bring new—new teaching methods and new information from health and education to all families in the Nation, I think you can turn it around and to start to get some feel for the kinds of things that—that you are—you are concerned about.

Mr. ROHRABACHER. Thank you very much, Mr. Chairman.

Mr. GILCHREST. Mr. Chairman, could I make a remark to the gentleman from California?

Mr. SWETT. Sure.

Mr. GILCHREST. Just very short.

I would agree with what—exactly what Dr. Massey said and Mr. Kearns said, but I would also say that some of those students that come from homes where there is no sense of the importance of learning; when they get into the classroom, if they're in a classroom with 35 or 38 kids, and its instruction—unless you have a really super teacher with the chalkboard, they lose, because they don't have that individual attention that someone under those circumstances needs in the classroom.

And this technology's going to offer that individual attention and that motivation that individuals need in the classroom, and it will free the teacher up to do that kind of thing.

Mr. KEARNS. Mr. Chairman, could I make just one last comment?

There's a lot of discussion around about technology replacing teachers. I don't know what teacher ratios are going to be in the next decade and so forth. But I do know one thing—good teachers will be the fundamental underpinning regardless of what technologies that we use of a good education system. And the training of our teachers over the next decade to improve their skills is also going to be absolutely key and a fundamental underpinning if we're—if we're to reach the—the national—national goals that have been established.

Mr. SWETT. I would like to thank you gentlemen for your testimony this morning. I have been struck by one overriding quality, and that is that there seems to be an openness of mind and an openness to approach that leads me to believe that both of you gentlemen have struggled with the ideas of conceptual blockbusting and have left yourselves open to new ideas and new techniques that might be helpful in the future.

I think that as we look at the educational system, certainly we strive to improve the individual relationship between student and teacher, between student and database. Certainly, computers, I think, have a major role in improving that individualization instead of standing before a class and doing rote work, there will be individualized terminals with a speed adjusted to that student for the dispersement and reception of information.

I think that is an exciting and very helpful approach. And I look forward to hearing more from you in the future.

At this time I'd like to call forward the second panel and excuse Dr. Massey and Mr. Kearns.

We will be hearing from Dr. Linda Roberts, Dr. Ronald Fortune, and Mr. Albert Shanker, Mr. Jeffrey Joseph, Dr. Leroy Tushcer, and Dr. G. Thomas Houlihan, in that order.

I would appreciate it if we could move as expeditiously as possible; we have a time constraint with one of our testimonies.

Our first witness on this panel is Dr. Linda Roberts of the Office of Technology Assessment. I understand that Dr. Roberts will have to leave us right after her testimony because she must be in Phoenix later today to receive a very pertinent and prestigious award. She has been chosen an Educator of the Decade, in Electronic Learning magazine's "Ten Who Made a Difference" Awards Program. The award, which is given only once per decade—that's an amazing distinction.

[Applause]

Mr. SWETT. Will be presented in a ceremony at the National Education Computing Conference being held this week in Phoenix.

Congratulations, Dr. Roberts. I waive the customary rulings—we will allow questioning for a very brief period after your statement. I understand you have to be out of here by 11:45, and we will comply with your schedule and appreciate your being here to testify. Please proceed.

STATEMENTS OF DR. LINDA G. ROBERTS, SENIOR ASSOCIATE, SCIENCE, EDUCATION, AND TRANSPORTATION PROGRAM, OFFICE OF TECHNOLOGY ASSESSMENT, WASHINGTON, D.C.; DR. RONALD F. FORTUNE, PRESIDENT, COMPUTER CURRICULUM CORPORATION, SUNNYVALE, CALIFORNIA; ALBERT SHANKER, PRESIDENT, AMERICAN FEDERATION OF TEACHERS, WASHINGTON, D.C.; DR. LEROY J. TUSCHER, PROFESSOR OF EDUCATION AND COMPUTER SCIENCE, LEHIGH UNIVERSITY, BETHLEHEM, PENNSYLVANIA; DR. G. THOMAS HOULIHAN, SUPERINTENDENT, JOHNSTON COUNTY SCHOOLS, SMITHFIELD, NORTH CAROLINA, AND JEFFREY H. JOSEPH, VICE PRESIDENT, DOMESTIC POLICY, U.S. CHAMBER OF COMMERCE

Dr. ROBERTS. Thank you very much, Mr. Chairman.

I want to say that it is a pleasure and an honor to be here, and in particular, when I accept the award tonight in Phoenix, I accept it on behalf of the Office of Technology Assessment and the work that we are doing. And it is very gratifying to see just how useful and relevant our studies of technology and education have been, not only to the Congress, but to the States and the localities as well.

With your permission, I'd like to submit my written testimony for the record and use this time to highlight some major points. And in fact, they are the points that have been made again and again this morning. And it is—it is very fortunate to be able to hear the leadership of two of the major agencies reinforce the things that we have been able to find in our assessments of technology and education.

Certainly today's computer-based educational technologies go far beyond the electric—early electronic textbooks. And as we will see later this morning, students can access texts, graphics, high resolution pictures, sounds, and voice, and even full motion video.

And advances in telecommunications, as Congresswoman Morella and others have noted, are bringing new resources to the classroom. And it is true, that linking is a very important and key idea for the future of our students in our classrooms.

American public schools have acquired more than 2 million computers in a decade, and computers are widely distributed and student access has improved.

America's clearly a leader in educational technology. Our most innovative software applications have become models for projects in other countries.

Just as there is no one best technology for schools, there is no one best use of technology and, certainly, we have heard that point made again and again this morning.

But new interactive technologies are contributing to improvements in learning, from helping to build basic skills through drills offering self-paced practice, to directing student discovery through simulations in science, mathematics, and social studies; and to encouraging cooperative learning as students work together on computer projects in the classroom or on electronic networks across the content—continent.

New technology is costly and schools have had to make difficult choices. Investment in technology is sometimes a trade-off between new learning tools and traditional text. In other instances, teachers have been given the choice of more computers or a teacher aide. We know that computer-assisted instruction can be a cost-effective method to raise achievement test scores in the short run. And this evidence has spurred further investment.

But for many educators, the appeal of the computer and computer-based technologies is based on the hope that it will change the way students learn and have profound long-term effect.

The future for technology is very promising because we have learned a lot in a decade. The original assumptions that we could use computers as automatic textbooks or as replacements for teachers were incorrect.

We are learning to think of technology as a tool, rather than a solution. We are also learning to take advantage of the flexibility and versatility of the technology, discovering applications that meet the needs of learners and teachers in diverse settings.

But these gains in education, I have to say, pale in comparison to the information technology applications developed by business, the military, medicine, and higher education. To exploit technology's power and potential for education, three issues must be addressed.

First, as we've heard again and again, technology is only effective in the hands of a well trained, enthusiastic teacher. We have a small cadre of accomplished teachers, but most teachers want to use technology but not have adequate training, time, or support to do so.

Second, despite the tremendous gains in software and applications that we will see today and as we've seen elsewhere, new development is critical. And it is the changes in the curriculum and the increased demands for higher order thinking skills that require that we develop new content, and that we develop this content and these approaches in the next generation of software and multimedia products.

Third, educational technology R&D is not keeping up with advancing technologies . There are many promising research directions to take, including the development of multimedia learning tools, intelligent tutoring systems, new assessment technologies, and software that helps teachers create and customize the teaching materials that they need for their students.

Research efforts could bring together what we know about learning, what we are seeing happening in information technology and, most importantly, schools and teachers willing to experiment.

In closing, I want to emphasize that now is the time to develop a comprehensive Federal policy, that allow schools to acquire the technology they need, that supports teachers' development, that builds research into practice, and integrates technology in the process of school reform and restructuring.

One opportunity may be the proposal to create demonstration schools across the Nation. If Congress supports this proposal, the model schools would offer a rich seed bed for testing the best of today's technology applications, and designing the next generation of tools for teaching and learning.

Of course, other schools could be linked for the same purposes. Much attention has focused on the power of technology to improve student learning. At least equally powerful and promising is the potential for technology to train, support, motivate, and connect teachers in the classroom. And the technology could be a critical element in spreading the impact of school experimentation and reform from one location to students and teachers all across the Nation.

Thank you. I'd be happy to take questions.

[The prepared statement of Dr. Roberts follows:]

EDUCATIONAL TECHNOLOGY: NEW TOOLS FOR TEACHING AND LEARNING

STATEMENT OF DR. LINDA G. ROBERTS
Senior Associate
Science, Education, and Transportation Program
Office of Technology Assessment
Congress of the United States

Testimony Before the
Subcommittee on Technology and Competitiveness
Committee on Science, Space, and Technology
U.S. House of Representatives

June 18, 1991

Thank you for the opportunity to testify and provide an overview of educational uses of computers and new information technologies in the United States. My remarks will draw on OTA's assessments of computers in education[1] and telecommunications technologies for learning at a distance.[2] (Summaries are attached.) These reports and related OTA work in science and mathematics education[3] focus on the impacts of technology in K-12 education over the last decade. Although the first attempt to use computers with school children dates back to 1959 and early experiments with distance learning by satellite occurred in 1973, a dramatic infusion of technology in our schools began in the 1980s and has continued to increase (see figure 1). The most recent data suggest that schools' acquisition of CD-ROM technology, laserdisc, local area networks, satellite dishes, and modems is following a similar trend (see figure 2).

Early experiments with computers and telecommunications involved few students and teachers, and the technologies had very limited capacity. Today computer-based technologies go far beyond early "electronic textbooks." In addition to text, computer-based systems now have access to high-resolution pictures, sound and voice, and full-motion video. The systems can be self-contained in classrooms or can include technology that links one classroom to another, to other schools, to other communities, and most importantly, to other information resources.

This linking technology is especially important, because it goes beyond the classroom and can enlist the Nation's network of science centers, museums, and other informal educational programs. It can also link schools to our colleges, universities, and research centers (e.g., Federal laboratories).

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[1] U.S. Congress, Office of Technology Assessment, *Power On! New Tools for Teaching and Learning* (Washington DC: U.S. Government Printing Office, September 1988).

[2] U.S. Congress, Office of Technology Assessment, *Linking for Learning: A New Course for Education* (Washington DC: U.S. Government Printing Office, November 1989).

[3] U.S. Congress, Office of Technology Assessment, *Educating Scientists and Engineers: Grade School to Grad School* (Washington, DC: U.S. Government Printing Office, June 1988).

American public schools have acquired more than 2 million computers in this decade. Computers are widely distributed and student access has improved. Schools have demonstrated a remarkable willingness to invite computer technologies into the classroom, and to see how these interactive cognitive tools could be applied for teaching and learning. The schools' eager embrace of computer technology has come about despite the constraints on local budgets, an ever-changing and often chaotic technology marketplace, and an institutional setting that does not easily adapt to technology. In comparison with other countries, our widespread diffusion of computers and large-scale experimentation puts us at the forefront of implementation. An installed base of computers provides a strong incentive for development of educational software, and our most innovative software applications have become models for projects in other countries.[4]

Is technology effective? I can assure the Committee that technology is beginning to play an important role in improving education in this country. There is no one best use of technology, but there are many promising applications for all learners -- at-risk students, the gifted, those with special learning needs, and others. The varied capabilities of the technologies are key to their power. OTA's assessments make clear that under the right conditions new interactive technologies contribute to improvements in learning -- from helping to build basic skills through drills offering self-paced practice, to directing student discovery through simulations in science, mathematics, and social studies, to encouraging cooperative learning as students work together on computer projects in the classroom or on electronic networks across the continent. I'd like to provide three examples.

1. At-risk youngsters have varying achievement levels and many are out of step and behind their peers in content mastery and some skills. Computers can provide individualized practice necessary to develop specific skills. For at-risk youngsters there is special value

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[4] I recently had the opportunity to participate in an evaluation of the Spanish Government's 5-year computer education initiative with a team of experts from France, Belgium, and Scotland. We were later joined by experts from all the OECD member countries. I learned that OTA's reports and videos depicting the U.S. use of technology in education have been broadly disseminated throughout Europe.

in practicing at one's own pace until the learning takes hold, rather than being moved along in lockstep with the rest of the class before mastery has been achieved. At the same time, technology can easily provide records of student progress, enabling teachers to better understand students' stumbling blocks, gaps in learning, and misconceptions. Skill practice is not enough however; these students need more powerful, rich, and versatile resources that can be provided by today's computer and multimedia technology.

2. Technology supports learning in reading and writing -- the fundamentals for literacy and foundations for learning in all subjects. Key strategies that are essential for reading, critiquing, and improving written work are being incorporated into software programs, which when coupled with appropriate instruction can enhance students' writing facility, interest, and skills. Students who succeed in their own personal communications often change their attitudes about reading, writing, and school. Through the use of desktop publishing or electronic networks for writing, students write for a purpose, communicate with their peers, and come to see that they can move beyond the limitations of their own environment.

3. In the teaching of math and science, technology brings new resources into the classroom. Students measure acid rain, track the effects of recycling household trash, and take part in a simulated mission in outer space. With access to electronic networking and software databases youngsters conduct collaborative research with other student scientists around the country. Some projects also link students with working scientists. They learn to value themselves as contributors to solving problems of importance to their community and their country. Technology offers enormous potential

for attracting more students into science. This is because it enables them to actually "do science" -- gather data, participate in experiments, work out hypotheses, and interpret findings.

In the course of acquiring new technologies schools have had to make difficult choices, often asking the question: how much do new instructional technologies cost and are they worth it? Schools' investment in technology is sometimes a tradeoff between new learning tools and traditional texts. In other instances, teachers have been given the choice of more computers or a teacher aide. Could reductions in class size bring about similar achievement gains at lower cost? These questions are not easily answered.[5] But there is also the question of short-term and long-term effects. OTA found evidence that computer-assisted instruction can be a cost-effective method to raise achievement test scores in the short run. For many educators, however, the appeal of the computer is based on the hope that it will change the way students learn and have profound, long-term effects.

The future for technology is very promising because we have learned a lot in a decade. The original assumptions that we could use computers as automatic textbooks or as replacements for teachers were incorrect. We are learning to think of technology as a tool rather than a solution. We are also learning to take advantage of the flexibility and versatility of the technology, discovering applications that meet the needs of learners and teachers in diverse settings.

Modern technology brings new resources into the classroom. It links learners together in new ways. It supports teachers. These new tools for teaching and learning are transforming the educational process.

But these gains in education pale in comparison to the information technology applications developed by business, the military, medicine, and higher education. Only a handful of classrooms have one computer for each child and another one for the child to use at home.[6] And few schools have been built or remodeled to take advantage of computer and networking capabilities. While most teachers want to use computers, few consider themselves adequately prepared to teach with them. Most applications remain that of isolated drill and practice. In general, classrooms today resemble their ancestors of 50 and 100 years ago much more closely than do today's assembly plants, scientific laboratories, operating rooms, and businesses.[7]

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[5] However, in the military and business, educational technology has proven to be cost-effective.

[6] Even though K-12 schools now average 1 computer for every 20 students, most schools still do not have enough computers to make them a central tool of instruction.

As we consider how to exploit the power and versatility of technology now and in the future, there are issues that must be addressed. First, technology is only effective in the hands of well-trained, enthusiastic teachers. There is a small, but growing cadre of "accomplished teachers" in our schools who have been able to integrate computers into classroom practice.[8] Teachers need training, time, and support to learn and incorporate technology into their teaching. When these elements come together, teachers report that using the computer has changed their teaching in fundamental ways, and they become more like coaches and facilitators. Efforts to expand the use of technology must include necessary training and support to the overwhelming majority of teachers who are not yet "accomplished" users.

Software development will also be critical. Changes in the curriculum and the increased demands for higher order thinking skills means that content is the main problem to be addressed in the next generation of software and multimedia products. Although there are more than 10,000 products on the market and despite the steady improvement, the quality of educational software could be much better. The increased capacity of hardware and advances in programming have removed many technological barriers, but economic risks in the market lead software publishers to play it safe. Efforts to encourage public-private partnerships have been very successful. One example is the

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[7] One example is that at the 1991 Computerworld Smithsonian Awards program last week, Frito-Lay was honored for its achievements in advancing the use of computers -- the design of a system (a hand-held computer and electronic network) that enables each salesperson and corporate headquarters to track some 14 million items in 400,000 locations every day -- changing the way the company does business.

[8] See Karen Sheingold and Martha Hadley, Accomplished Teachers: Integrating Computers Into Classroom Practice (New York, NY: Bank Street College, Center for Technology in Education, 1990).

National Geographic Kids Network materials created jointly by the Technical Education Research Centers in Cambridge, Massachusetts, and the National Geographic Society with funding from the National Science Foundation (NSF).

Many innovative projects have focused on mathematics and science, but other areas of the curriculum including the arts and humanities need attention as well. New developments in multimedia technology have captured the imagination of the education community. Multimedia software makes it possible for students to study works of art and literature, and musical compositions. The same technologies provide students with tools to create graphic, sound and visual images.[9]

Much has been learned from research and development (R&D) efforts funded by the Federal Government. The Department of Defense has played a major role in the development of computer technology and its applications to education and training. More recently, a number of advanced technology applications have been funded by the National Science Foundation. As we noted in *Power On!*,[10] a substantial investment in R&D is needed to exploit more fully the power and potential of technology for education.

There are many promising research directions including intelligent tutoring systems; tools that help students move beyond low-level tasks and concentrate on more demanding problem solving skills; new assessment technologies that track learning, diagnose students' conceptual understanding, and evaluate the attainment of complex skills; and design tools and kits that enable teachers to create and customize their own teaching materials. R&D efforts could bring together research on learning, developments in information technology, and schools and teachers willing to experiment.

Now is the time to develop a coordinated Federal policy that allows schools to acquire the technology they need, supports teachers' professional development, builds research into practice, and integrates technology into the process of school reform and restructuring. In addition, it is very important that these efforts build in careful evaluation, with transferability considered a key issue. Congress has begun to act. Recent legislation in mathematics and science education, the Star Schools Program, and proposed legislation for adult literacy, teacher education, and foreign language instruction all encourage use of technology. There are other opportunities ahead.

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[9] Many of these new developments were demonstrated and discussed at the conference sponsored by the Getty Center for Education in the Arts, "Future Tense: Arts Education Technology," Los Angeles, CA, Jan. 24-26, 1991.

[10] Office of Technology Assessment, op. cit., footnote 1.

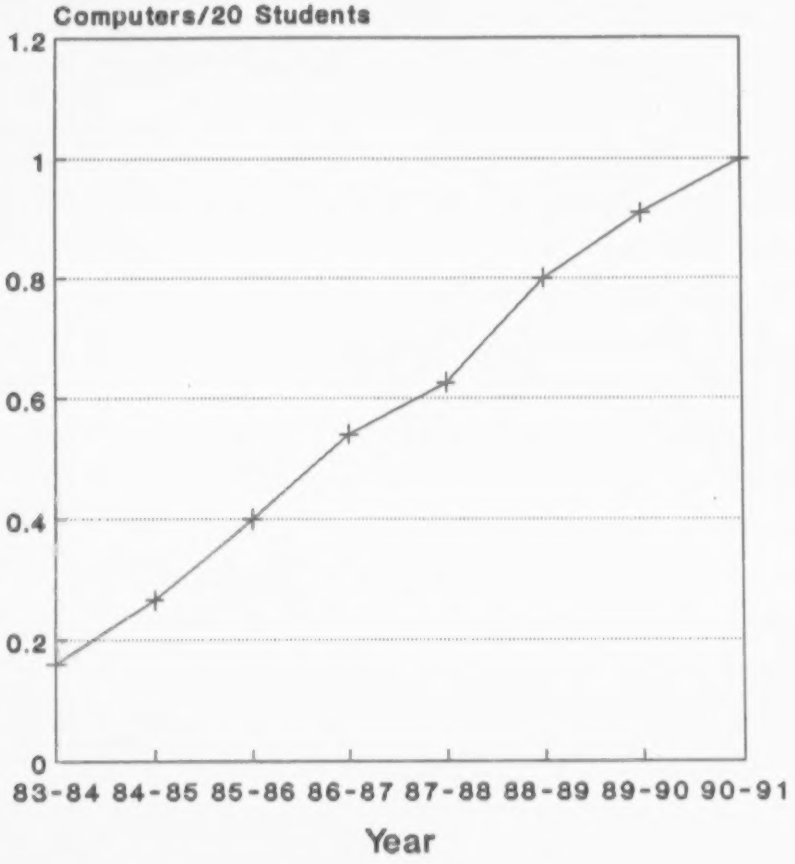
One opportunity may be the President's proposal to create 535 demonstration schools across the Nation. If Congress supports this proposal, the model schools would offer a rich seed bed for testing the best of today's technology applications and designing the next generation of tools for teaching and learning. Of course, other schools could be linked for the same purposes.

Effective use of technology must involve teachers and local school districts, other educational institutions, States, the Federal Government, and the private sector. The Jason Project, for example, was a collaborative effort of the Woods Hole Oceanographic Institute, the National Science and Social Studies Teachers organizations, science museums and centers, the EDS Corporation, the Turner Broadcasting Network, and the Federal Government. Congress could make clear that technology can play an important role in the reform and restructuring of the Nation's schools.

Much attention has focused on the power of technology to improve student learning in today's classrooms. At least equally powerful and promising is the potential for technology to train, support, assist, motivate, and connect teachers in the classroom. Just as teachers and students in Montana are linked through the Big Sky Telegraph Network, telecommunications can link experimental schools to each other to collect data, share ideas, and expand access to resources. Similarly, the technology could be a critical element in spreading the impact of school experimentation and reform from one location to students and teachers all across the Nation.

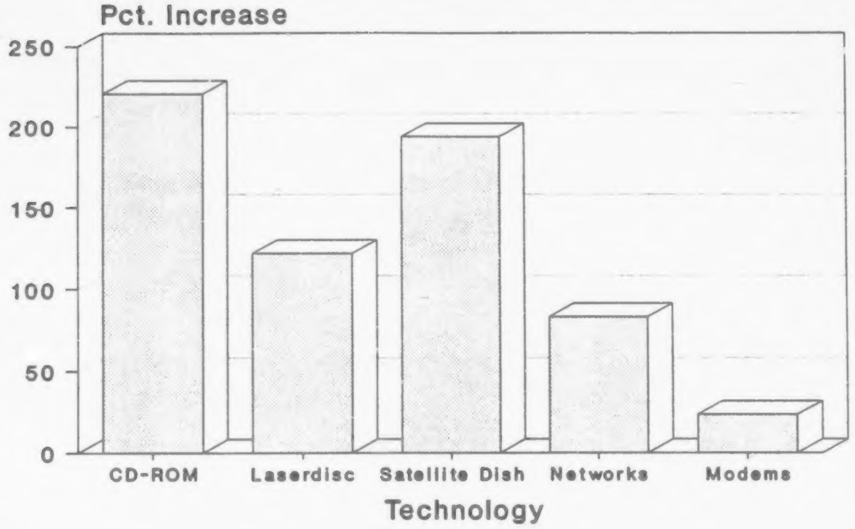
FIGURE 1

Average Number of Computers Per 20 Students in U.S. Public Schools, 83-91



Source: Office of Technology Assessment,
Based on data from Quality Educational
Data, 1991.

FIGURE 2



New Technologies in K-12 Education
3-Year Trend

Number of School Districts

Technology	88-89	89-90	90-91
CD-ROM	429	810	1376
Laserdisc	472	921	1047
Satellite Dishes	1068	2336	3149
Networks	1567	2227	2873
Modems	2723	3316	3360

Source: Quality Educational Data, Denver, Colorado
"K-12 Public Schools, Instructional Use"

Mr. SWETT. Thank you very much.

I would like to follow on my remarks at the conclusion of the previous panel and explore a little bit a direction that you had in your testimony that talks about the use of technology versus the reduction in teacher/student ratios; and I'd like you to please comment.

Do you see this technology enabling teachers actually to establish better individualized relationships with their students and can you give a few examples of that?

Dr. ROBERTS. What our—what our research has demonstrated to us—and let me say this very clearly—is that technology doesn't replace teachers. What is much more significant is the fact that teachers who really become accomplished users of computers and interactive technologies and even television technologies , report that their—the way in which they teach, what they teach and how they teach is changing. And I think it is the change in teaching role that is far more significant than whether or not you have more students or less students.

We really don't know what the ideal applications are, yet, we need to explore this much more in the future.

Mr. SWETT. At this time I'd like to turn the microphone over to Congressman Gilchrest from Maryland.

We will go now on congressional protocol.

Mr. GILCHREST. Dr. Roberts, you spoke of model schools as a way that the Federal Government can begin planting the seeds for future school use of all of this technology.

Could you give us a little bit more on the model schools as far as—let me just set the stage, for example. Would it work where the Federal Government would come in and create a separate facility, or from the existing public schools where perhaps selective students from around the State would go to that particular new model school; or would you select, let's say, a public school system and use that as an experiment, or could you do both?

Dr. ROBERTS. Well, I think that perhaps there are no models of model schools, specifically. In other words, there are many. There are many efforts to demonstrate already effective use of technology and effective teaching across the country.

And if I understood Mr. Kearns' remarks, the intent of the proposal that the President has made is to build on the knowledge and the experience that we already have and—and set up, create demonstrations where teachers and members of the community, and other school districts can look at some of the newer ways or some of the more innovative ways to apply the best of what we know and, in fact, invent new approaches as well.

I think that we really—we really don't fully understand where technology can take us. And I want to point to the example of what's happened in—in Montana where telecommunications technology is being used to literally link that State's one-room schools all across the State. And while the original intent was to use this linkage to share ideas between teachers, one of the most interesting applications has become that of students working together on real problems related to social studies and science on the network itself. And it's the point that we have a whole range of models and applications that could be tried, some of which use technology, some of which may not use technology as well.

Mr. Gilchrest. That's fascinating. Thank you, Dr. Roberts.

Thank you, Mr. Chairman.

Mr. Swett. Thank you.

We'll now hear from my good colleague from Pennsylvania, Congressman Ritter.

Mr. Ritter. Mr. Chairman, I do not have any questions at this time.

Mr. Swett. Okay, we'll move on down the line.

Congressman Rohrabacher?

Mr. Rohrabacher. One question, Dr. Roberts.

You mentioned a lack of training for teachers in computers. I know my friends who are teachers have some great incentives to go back and further their education.

Are these incentives present to further their education in computer education as well?

Dr. Roberts. Well, what we found in—in the examples where—where teacher training for teachers already in the classroom has been very, very successful, is to provide teachers with the kinds of resources that enable them to do what they want to do better.

I think that's the most important incentive of all.

But—and there are many ways to do it. In some cases, the training can be provided by other teachers in the districts and in the school, training can be a partnership between schools and the universities. Training can also be accomplished in—in what I would say are fairly unique ways, even bringing in members of the community to help bring in new ideas and new applications for technology.

But the key is not just training, it's a whole set of factors that really have to be there to support teachers' use of technology. They have to feel comfortable with the technology. They have to have appropriate software that makes a difference in the way in which they can reach their students. And the technology has to—has to be accessible and available.

Some districts have found it very important to make sure, for example, that teachers can take computers home over the weekend, or home during their summer vacation so that they can spend more time and feel comfortable with the technology.

There—there are lots of ways that we can help teachers use technology. One of the most exciting projects we saw was an opportunity for teachers to watch other teachers use the technology. And in the future, they may be able to do that if they are linked by fiber or satellite; I mean, there's no reason why teachers can't take field trips as well as students.

Mr. Swett. We can be very grateful of the price of computers and computer technology has been going down in the last 10 and 20 years dramatically, which, of course, should open up new avenues in education.

And I'd just like to congratulate you again on your award, and thank you for your testimony today.

Dr. Roberts. Thank you very much.

Mr. Swett. The microphone can now be turned over to Congresswoman Morella.

Mrs. MORELLA. Thank you and I'll make it brief. And, again, my congratulations—very, very proud of you.

I wanted to pick up on something that I read in Dr. Fortune's testimony that relates to what you mentioned pilot projects, and we've talked—the earlier speakers also mentioned the President's AMERICAN 2000 strategy.

But what Dr. Fortune says is he says, No, what we might do is recommend the inclusion of extensive CBI technology into the pilot school program; and he talks about every classroom should have a critical mass of student computer stations, 6 to 8, and a few other little items—2 to 3 specialized 30-station computer labs; and for each teacher a presentation station, work station.

Should Congress be involved in terms of specifically stating that we should have CBI technology as a component; what do you think?

Dr. ROBERTS. Well, in my view, and this is my view, and it's based on years of experience with schools and all of the discussions we've had with people around the country—what Congress can do is encourage the use of technology.

But I really don't think you want to specify how that technology, what technology, or how that technology gets used. I want to emphasize again, that there really is no single best technology for our schools. There are many technologies that can be utilized and, in fact, are already being utilized in increasing numbers throughout the country.

Mrs. MORELLA. But, should we say that these pilot schools should have a component or look to the computer-based instruction , or should we just leave that again to academic freedom or whatever?

Dr. ROBERTS. Well, I would hope that most of the schools that—that if they are created, would want to use technologies as a resource. I really have not found any school districts that—or schools, or teachers, in fact, who have said, I don't want to use technology.

What they have said is that the choice of using technology is in fact a difficult choice; it's always—it's always a trade-off. And I think that what we want to be sure to do is encourage the use of technology, not discourage it.

And there are partnerships that have already occurred between schools and the private sector that I—that have created some very interesting and important demonstrations, whether we're talking about the Apple classrooms of tomorrow, or some of the IBM sites, or some of the work that I know that Ron Fortune's company has been doing with schools around the country.

Those—those examples are important. And the experience that we've had with technology over the last 10 years is also very important. And I think we need to build on that experience.

Mrs. MORELLA. So encourage, don't mandate. Thank you.

Mr. SWETT. Thank you very much. It is 11:45. You have just had a display of Congress at its most efficient and best. And I thank you and congratulate you again for your award, and you are free to go.

Dr. ROBERTS. Thank you very much.

Mr. SWETT. We will revert back to a procedure where we'll have all testimony given and then we'll have questioning of the panel.

At the conclusion of testimony , I would ask that you try to summarize as briefly as you can.

And we'll start off with Dr. Fortune, whom I'm advised has made all the arrangements for the systems demonstrations that will follow this hearing. And the subcommittee wishes to thank you for what is obviously a lot of effort on your part and for making it possible for us to actually see this technology in action.

Please proceed with your testimony.

Dr. FORTUNE. Thank you, Mr. Swett.

Mr. Chairman and Members of the subcommittee, it is a pleasure and an honor to address the Subcommittee on Technology and Competitiveness.

I have been asked to address the technology and implementation aspects of computer-based instruction, better known as CBI. I will focus my remarks on three areas:

the current and future technologies required for the growth of CBI;

the impediments for massive implementation of computer-based instruction , and

recommendations for the Federal Government's role in encouraging the implementation of computer-based instruction.

My extended remarks can be found in the testimony which I have submitted.

Extensive research supports the premise that computer-based instruction is an effective and efficient approach to the education of Americans for the competitive, aggressive, high technology world of the future.

Given the positive contribution that CBI has had, and will continue to have, in educating our citizens, the key question is: What types of technology are critical to the growth of computer-based instruction ?

It is significant to note that the critical technologies for the growth of CBI are grouped into two categories, hardware and software. On page five of my testimony and on the chart to the left you can see the list. I will briefly describe three areas that are important to the continued growth of computer-based instruction .

[Charts.]

Dr. FORTUNE. The first, as Dr. Roberts indicated, is multimedia technology, which will change the scope and reach of interactive systems. The possibility of dynamically presenting speech, pictures and sound under computer control will open areas that have been beyond the reach of computer-based instruction. We will have demonstrations of educational multimedia software at the end of this hearing.

The second is pen-driven technology which requires the learner to use pens for computer input instead of a keyboard or a mouse. This technology is quite portable. In the future, students will carry their personal computer notebooks from class to class and to home.

Thirdly, artificial intelligence will approximate the construction of an intelligent tutor for each student. For example, some educational software in mathematics has small expert systems which will diagnose a student's error, and in that way the student can get the appropriate tutorials.

A survey of international activities in computer-based instruction indicates that the United States is the most prodigious producer and user of CBI software. Many countries are developing CBI and teaching computer literacy skills, most notably, Japan, several Western European countries, and Israel.

Likewise, a comparison of specific CBI technology indicates that the United States is in a strong position vis-a-vis international competition. I refer you to page nine in my testimony and to this additional chart.

You can see the technologies where we are strong, where we're losing, and where we've lost to the competition.

While the United States currently is strong in many of the technologies related to CBI, will this country take advantage of those technologies?

For instance, many schools have found it difficult to implement computer-based instruction. I have identified six impediments to progress:

the high, yet declining cost;

the lack of sufficient, high quality teacher training, as Dr. Linda Roberts pointed out;

the difficulty of integrating computer-based instruction into the standard school curriculum;

teacher resistance to computer-based instruction;

rapid hardware obsolescence, and;

the lack of hardware standardization.

Some improvements are taking place in these areas, but progress is quite slow.

What can the Federal Government do?

There are a number of coordinated steps that the United States Government can undertake to provide a catalyst to the development and use of computer-based instruction technology.

Recommendation No. 1: The pilot schools proposal that has been talked about quite a bit this morning.

President Bush's America 2000 Strategy proposes the creation of 513 new American schools to promote better education. I recommend the inclusion of extensive computer-based instruction technology into the pilot school programs. For example, each school should have the following:

First, every classroom must have a critical mass of student computer stations. I would recommend six to eight stations.

Second, two to three specialized 30-station computer labs, that might be in science, math, and in other areas.

Thirdly, and most importantly, for each teacher, we need a presentation work station and a computer at home for the teacher.

The second recommendation: The development of an information highway that you, Congress Morella pointed out.

The creation of a high-speed, fiber optics network connecting schools, homes, and others to a national data resource has been proposed. This is an area where the United States can serve as a catalyst, since many of the technologies that are now developing will only reach their full potential if the connectivity and storage capacity of the information highway is only available.

As you know, Japan already has a $20 billion project under way to build an information highway. We must remain competitive.

Recommendation No. 3: Sponsor a CBI intergovernmental coordination effort.

I applaud the efforts of the FCCSET Committee, which has been referred to numerous times this morning, for its establishing strategic objectives for mathematics and science education.

A similar approach could be used to coordinate U.S. Government activities in the area of computer-based instruction.

This coordination of government-sponsored computer-based instruction activities should focus on efficiency, effectiveness, validity and replicability.

Recommendation No. 4: Support the adequate education research funding.

Lastly, I recommend an increase in U.S. Government funding for research. As suggested above, such funding should be strategically focused on the coordination of the broad range of research activities that will contribute to the electronic schools of the future.

In conclusion, there have been four major milestones shaping education:

the development of the writing system in 3500 B.C.;

the organization of the first library in 300 B.C.;

the development of the printing press in 1440;

the development of mass schooling in the 1800's.

The use of computer-based instruction will represent the fifth great milestone in education.

Thank you very much.

[The prepared statement of Dr. Fortune follows:]

Computer-Based Instruction -- Technology & Implementation

Dr. Ronald F. Fortune
President, Computer Curriculum Corporation

Presentation before the Committee on Science, Space, and Technology:
Subcommittee on Technology and Competitiveness

June 18, 1991

The U.S. has invested a great deal of research, development, and high expectations in computer-based instruction (CBI) during the past 25 years. CBI is an application of technology to a collection of teaching methods and has generated much excitement among educators who recognize the computer's potential as an instructional delivery medium. Research to date shows that well-designed CBI can markedly improve student performance and motivation. Recent cost-benefit analyses show that CBI can be a low-cost, effective resource for providing instruction.

CBI also offers benefits that the more traditional classroom teaching methods cannot provide. For instance, it can support individualized learning so that students can proceed at their own pace regardless of their ability level. Along with instruction, CBI configurations can provide access to information databases and serve as media for long-distance communication. In some applications, a combination of instruction, information access, and communication capabilities can provide unique and stimulating learning experiences that cannot be duplicated by any other teaching methods.

This paper will address the technological and implementation aspects of computer-based instruction by examining the following:

- Types of CBI
- Demonstrated results of CBI
- Cost-effectiveness of CBI
- Critical technologies
- Impediments to progress
- Recommendations

Types of Computer-Based Instruction

Integrated Learning Systems (ILS). The most educationally advanced type of CBI is the ILS. Integrated learning systems are characterized by networked microcomputers, a comprehensive curriculum, a uniform user interface, an instructional management model, user reports on performance, and an implementation model that includes teacher training. Some ILSs have been designed to individualize learning by adapting to the learner's performance. Other systems function as intelligent tutors, in that the curriculum is organized around learning models that take into account what the student knows, what the student's weaknesses are, and what the optimal instructional activities are in order to maximize the efficiency level at which a student can learn. Because these models have been tested with thousands of students, once the student's mastery rate in a subject area is estimated, a precise trajectory can be constructed for the student which prescribes the amount of time required to master a larger body of material. With some ILSs, teachers can forecast when individual students or groups of students will complete a one-year mathematics program, for example (Suppes, et al, 1988). One of the significant contributions of CBI is to incorporate validation procedures into the instructional models of how students learn. In this way, CBI can become authentic laboratories of educational investigation in which the learner teaches how to teach.

General application software. In contrast to the comprehensive approach of the ILS, general application software represents a set of computer-based tools that may or may not relate to the curriculum or to each other. General application programs include: word processors, database programs, spreadsheets, reference works, and other productivity tools. Some of the newer software in this area is available on CD-ROM disks. As a result of huge storage capabilities on optical media (CD-ROM and video disk), entire encyclopedias, dictionaries, atlases, and numerous other reference works are becoming available on-line.

Educational software packages. Unlike general application programs, educational software is designed specifically for use in classrooms. This category of software is usually used on a single station, although many of these programs can be networked. Usually software in this category is used for skill reinforcement, to provide student tools, or for providing micro worlds/ environments. One example of innovative educational software in the area of science is microcomputer-based laboratories (MBL), which use computers in school science laboratories to help students collect, analyze, and display data (Linn, 1986). Measurement instruments such as thermometers and light meters are connected directly to computers that record the measurements these instruments make, and the results can be displayed in real time while they change. Students use instructional software to manipulate and present the data and to answer questions about their interpretations of the findings. Most educational software packages are designed for math, reading, language arts, or science.

Distance learning. Distance learning systems represent the convergence of three informational technologies: the computer, telecommunication, and television. Distance learning allows a teacher to interact with students over great distances. A teacher in San Antonio, Texas, can provide Spanish instruction to students in Minnesota, for example. Additionally, this technology allows for interaction between the student and teachers, and for interaction between students.

Functional learning environments. Another way to use computers in the classroom is as a tool or a communication medium, not just for distance learning, but for networked, interactive communication and collaborative learning. For instance, high school students can participate in actual scientific experiments by collecting data in their locale and transmitting their findings via electronic mail to scientists who synthesize findings from various sites. Another example that has been researched extensively is a student-run newswire service that is disseminated over an electronic network to other students in distant locations. Students write their stories with word processors and can instantly transmit them around the U.S. Research has found that this kind of activity increases student motivation, improves their writing skill, promotes creative thinking and problem solving, and establishes cooperative work skills (Riel, 1989).

Demonstrated Results of Computer-Based Instruction

A growing body of research demonstrates that computer-based instruction can be designed and implemented to deliver effective instruction in a variety of subject areas and for a variety of students. (See Appendix A.)

Learning. The most common focus of research about CBI is its impact on learning. Hundreds of studies have shown that well-designed CBI can successfully teach a wide range of subjects (for reviews, see Becker, 1986; Krendl & Lieberman, 1988; Lieberman, 1985; Niemiec & Walberg, 1987). Many studies have found that CBI can be more efficient than traditional classroom teaching, in that learning time is reduced, students enjoy using the computer, and their attitude toward the subject matter often improves.

In addition to qualitative evaluations of the use of technology in the classroom, there must be quantitative evaluations of the effectiveness of the technology on learning outcomes. One district-wide longitudinal study in Maryland, for example, showed that the district scores on standardized achievement tests increased over a six-year period so the district rose from 14th place to 3rd in the state (Austin, 1987). A summary of a body of studies of about 10,000 Chapter 1 students showed an average gain of 7 NCE units. This represents a mean achievement growth of 1.3 years per year, a meaningful change relative to the typical growth of .7 year per school year for Chapter 1 students (Zanotti, 1984-90).

Transfer of skills from CBI to other settings. Newer CBI software has been designed to give students practical applications for problem solving in simulations and games. Some of these applications make abstract concepts visual and concrete, provide immediate feedback on the accuracy of students' thinking, and encourage students to think about their own thinking strategies. As more CBI software has been developed to teach higher-order thinking and problem-solving skills, some investigators have focused on the student's ability to transfer these skills from the specific software environment to other learning and problem-solving environments.

Cost-Effectiveness of Computer-Based Instruction

Accounting for all the main ingredients needed to provide instructional services with CBI, a few researchers have conducted cost-benefit analyses of CBI compared to other educational interventions. One study contrasted CBI instructional activities in reading and mathematics with peer and adult tutoring in these areas, reduction of class size by five students per class, and extension of the school day by one hour that was equally divided between reading and mathematics (Levin, 1986). The most academically effective intervention per dollar spent was peer tutoring, followed by CBI, reducing class size by five students, extending the school day, and adult tutoring.

Further analysis indicated that the effectiveness of CBI fluctuated depending on the way it was implemented at the local site. The cost of delivering CBI, along with providing adequate personnel and other resource support, varied widely from school to school. Sites that spent the most money per student to deliver CBI showed the highest gains in learning. Calculated as a ratio, the cost effectiveness (learning gains per student compared to dollars spent per student) improved as the money spent on CBI per student increased. Levin recommends that schools should use their CBI resources to full capacity in order to reap the most benefits, instead of underutilizing them as is typically the case.

Critical Technologies for CBI

The critical technologies for CBI can be grouped into hardware and software technologies. The following list represents the key components for CBI systems:

Hardware	Software
Microprocessor	Operating systems
Magnetic information storage	Graphics software
Laser devices	Database systems
Hardcopy technology	High-performance computer networks
Displays	Handwriting recognition
Optical information storage	Speech recognition
Memory chips	Artificial intelligence
Graphics hardware	Text-to-speech
High-performance computer networks	Learning models
Pen-input computers	Video compression/decompression
Video compression/decompression	

We single out four technology areas that appear to be important to the continued growth of CBI. These are:

- Multi-media
- Pen-driven systems
- Artificial Intelligence
- Databases

Each of these areas is discussed below, with particular consideration to the special issues involved in CBI application.

Multimedia. Multimedia is generally defined to be a combination of media for communication and interaction, including text, graphics, photos, sound, and full-motion, computer-controlled video. Multimedia represents a variety of hardware and software technologies, including the following:

- speech synthesis and recording
- video display
- high-bandwidth storage and transmittal
- video and speech compression and expansion
- authoring software

The development of these separate technologies, and their smooth integration, is a major challenge being undertaken by a variety of research and commercial groups throughout the world.

Multimedia appears certain to create a marked shift in the look and feel of almost all interactive systems. In particular, education is likely to be very heavily affected, with CBI programs containing multi-media elements.

Multimedia will change the scope and reach of CBI. Subjects such as social science, geography, music, art, and science may well see the first complete CBI implementations with the introduction of multimedia technology. The possibility of dynamically presenting speech, pictures and sound under computer control will open up areas that have been beyond the reach of CBI.

Pen-driven Technologies. A number of companies are preparing hardware and software systems that will use pens for user input instead of traditional keyboard and mice. These systems are expected to broaden the application of computers. I see this as a very important technology for education.

Just as multi-media technologies will increase the range of applications for CBI, pen-driven technologies will make it possible to use computers everywhere in the educational process.

Visionaries have long expected that each student would have his own computer system, would carry it from class to class, and use it at home. Until now, the size of the keyboard--the largest current element in today's portable computers--has been the significant limitation on size and flexibility of use.

Pen-driven computers will realize this dream with computer systems that are the size of a small notepad. Students will be able to write on the screens of these systems, with the system recognizing the handwriting and storing it as text. With the introduction of these systems, we can expect to see a new range of educational activities.

Artificial Intelligence. Multi-media increases the computer's ability to create a rich environment. Pen-driven input systems will move the computer into new physical settings. Artificial intelligence (AI) will increase the computer's tutorial capabilities and enhance the relevance of its decisions to each individual student.

The last several decades of research in artificial intelligence have resulted in a number of emerging technologies. These include natural language understanding systems, speech-recognition hardware and software, and expert systems for embedding decision-making knowledge into the software.

Many of today's educational systems use some of these capabilities. For example, programs that analyze a student's writing typically embed knowledge about English syntax and lexicons into the program. This is an example of the application of natural language processing. Also, programs that teach mathematical logic and advanced mathematics employ AI models of mathematical reasoning to assist in proving theorems. Finally, some programs have small expert systems to diagnose a student's errors in arithmetic exercises and can provide the student with highly tutorials to help each individual student.

Several things are needed to realize the promise of AI, including the following:

- Powerful computers: AI systems require more CPU power and memory. I expect that the marketplace will provide adequate power for sophisticated AI systems within the next five years.

- Adaptation of existing AI techniques: Many techniques, such as text and style checking, will need adaptation for student use.

- AI learning models: New models, based on such AI techniques as expert systems, will be required. For example, systems that tutor students in physics by understanding their underlying misconceptions about physical principles may be possible.

Databases. Within the next few years, we can expect an increasing amount of the world's storehouse of information to be organized in databases for computer access. Such databases will contain many kinds of data (photos, films, text) and will offer new access methods.

Multi-media techniques will store and present a variety of data, and AI techniques will offer the means to access the data easily and efficiently. We can expect large, national databases that can be accessed through new telecommunications means.

Looking ahead. A survey of international activities in computer-based instruction indicates that the U.S. is the most prodigious producer and user of CBI software. Many countries are developing CBI and teaching computer literacy skills, most notably Japan, several Western European countries, and Israel. Likewise, a comparison of specific CBI technologies indicates that the U.S. is in a strong position vis-a-vis international competitors.

Competitive Comparison of CBI Technologies

Where we're strong ...	... where we're losing ...	... and where we've lost
Microprocessor*	Laser devices*	Optical information storage*
Magnetic information storage*	Hardcopy technology*	Displays*
Operating systems*		Memory chips*
Graphics hardware & software*		
Database systems*		
High-performance computer networks		
Pen-input computers		
Video compression/ decompression		
Handwriting recognition		
Speech recognition		
Artificial intelligence		
Text-to-speech		
Learning models		

* Source: "Gaining New Ground" (Council on Competitiveness)

However, while the U.S. currently is strong in many of the technologies related to CBI, it may not be in the best position to take advantage of those technologies. The following section highlights some of the obstacles that must be overcome in order to fully realize the capabilities and promise of computer-based instruction.

Impediments to Progress

Many schools have found it difficult to implement CBI and other computer-based learning activities into the standard curriculum. Following are several obstacles they face.

Cost. It is expensive for schools to integrate CBI into the curriculum. Not only must equipment -- including computers, printers, and storage devices -- be purchased, but it must be installed and maintained, schools must provide a secure facility to house it, teachers must be trained to use it effectively and integrate it successfully into the curriculum, and the cost of new software and computer supplies must be budgeted. Other potential costs include the value of the trade-off between the teacher's time spent on CBI preparation and presentation versus time that could be spent on other educational activities.

Teacher training. Many schools would need to invest a great deal of money to train their teachers to use CBI effectively, and training dollars are dwindling in the 1990s. Yet CBI is best implemented by well-trained teachers. Some schools and school districts, aware that their teachers lack preparation, are reluctant to impose CBI on an untrained teaching staff. Most teacher training efforts provide only an introduction to the technology and fail to focus on effective instructional applications of CBI or how to use the technology as a teaching tool (Marshall, 1989). Training efforts also fail to integrate the results of research about the effectiveness of CBI, thereby missing opportunities to assure teachers that they are preparing to use a powerful educational resource (Glenn & Carrier, 1986).

Integration into the standard school curriculum. Innovative CBI software is not always tied directly to schools' curricular goals. Often it is up to the teacher to integrate CBI into existing lesson plans, and this places a heavy burden on individuals who are already overworked. As Mary-Alice White observes in an article on trends in education and technology, asking teachers to integrate new technologies into the traditional curriculum is "like asking the Wright Brothers at Kitty Hawk if their airplane could be integrated into the Virginia train schedule" (White, 1989).

Teacher perceptions of CBI. Teachers have been increasingly made accountable for raising their students' scores on standardized tests. They are reluctant to introduce CBI into the classroom unless they are assured that it addresses the school's established curricular goals and can improve student performance on tests. Most teachers recognize that the computer is an important teaching tool and that computer literacy is an essential set of skills for their students to develop. Yet many are not convinced that CBI is the best way to spend precious classroom time.

Hardware obsolescence. Schools that purchased computers just a few years ago are finding that their equipment is already obsolete and unable to run some of the newer instructional software available today. It is difficult for school administrators to justify large investments in hardware when they are aware that the equipment they buy today may be outdated very soon.

Standardization. The market for CBI is fragmented, so it is difficult for software companies to create or market CBI amid all the diversification. Schools vary widely in the hardware they use and how it is configured -- in classrooms, laboratories, or libraries. Without an installed base of consistent and unchanging hardware, most vendors are reluctant to invest the huge sums it would take to create state-of-the-art software. School's instructional goals and policies regarding the use of CBI may also differ, so software companies cannot create CBI that always matches a school's needs.

From the school's perspective, a decision to buy one type of hardware means that the school can only use software that is compatible. Rarely do schools have the variety of hardware it would take to run all the CBI software available, so their range of choice is limited to the software that runs on the school's system(s).

Recommendations

Many changes must occur to bring about the expected increases in the application of CBI. Private industry will produce most of the purely technological changes such as improvements in CPU and display technology. The educational research community, with a variety of funding sources, will continue research into the methods of the effective application of CBI technology. Local school districts will develop their own implementation plans and provide examples of successes.

There are a number of coordinated steps that the U.S. government can undertake to provide a catalyst to the development and use of CBI technology. Four such important steps are described below.

Pilot schools. President Bush's "America 2000 Strategy" plan proposes the creation of 535 "New American Schools" to promote new programs. I recommend the inclusion of CBI technology into the Pilot School program, with particular emphasis on implementation plans, evaluation programs, and replicability studies.

Information highway. The creation of a high-speed fiber optics network interconnecting schools and homes to each other and to national data resources has been proposed. This is an area where the U. S. government can serve as a catalyst, since many of the technologies that are now developing will only reach their full potential if the connectivity and storage capacity of the Information Highway is available.

Governmental superagency to support CBI. The FCCSET Committee established strategic objectives for mathematics and science education. A similar approach could coordinate U.S. government activities and assure that any funding is focused on programs that will provide synergy to the application of CBI technology.

Funding. Lastly, I recommend an increase in U.S. government funding for research. As suggested above, such funding should be strategically focused on the coordination of the broad range of technological and research activities that will contribute to the school of the future.

Use of Technology to Strengthen Human Resource Development in the U. S.

After 25 years of research, development, and application, CBI can now contribute significantly to changing how this country prepares its citizens for the workplace as we move toward the 21st century. CBI offers a means of meeting many of the goals for education established by President Bush and the governors.

Basic skills for K-12 students. The use of CBI to supplement basic skills instruction is the most widely instructional use of computers in K-12 schools. Of the teachers using computers in elementary schools, more than 80 percent use software for basic skills instruction (Instructor Magazine, 1991). Although there is positive evidence that the use of CBI is effective in increasing student achievement, the following factors must be considered in selecting and implementing CBI: curriculum covered, learning model followed, and implementation strategy used.

Learning disabled students. CBI can effectively supplement classroom work for learning disabled, educable mentally retarded, and emotionally disturbed students. Learning disabled students have shown significant increases with CBI in mathematics achievement, reading skills, and spelling, compared to similar groups of students who did not use CBI. Emotionally disturbed students who have trouble relating to other people work alone successfully with emotionally "neutral" CBI lessons, and they remain on task with CBI longer than with classroom instruction.

Niemiec and Walberg (1987) reviewed the literature and found that the CBI programs studied were more effective for learning disabled students than for other students. They offer four reasons why learning disabled and disadvantaged students respond well to CBI.

(1) CBI is less threatening than classroom instruction, which requires in-class recitation.

(2) Learning disabled students benefit greatly from extensive drill-and-practice, whereas the more advanced students do not need that experience to succeed.

(3) CBI has built-in diagnostics, which may be especially useful to learning disabled students who need frequent and specific remediation.

(4) The presence of CBI may indicate that the school is giving other academic support and teaching resources to learning disabled students, so their academic achievement may be due to other factors in addition to the CBI they receive.

Advanced secondary students. There is at the present time a strong need to offer a variety of technical courses in high school, especially courses that deal with advanced technology and computer science. As an example, it is difficult to see how we will bring to many of the 23,000 high schools in the United States the resources to teach a first course in the programming language Pascal, especially at a level that will make it suitable for the students to take the advanced placement test in computer science, which is built around that language. It is possible to offer essentially complete courses by computer-based instruction. Such courses could be managed by teachers who are not themselves experts in the subject. The main responsibility for instruction in terms of presentation of material, assisting the student when help is needed, and evaluating student progress would fall to CBI. The administration of the course and the general problem of student guidance would fall to the teacher. This is a model that has been extensively tested in some universities, and there is every reason to think that it will be successful at the high school level as well (Suppes & Fortune, 1985).

Strategies involving programming courses also apply to advanced courses in math, science, and foreign languages. There are currently about 35,000 high school students a year taking the advanced placement examination in calculus, yet a fairly large number of high schools in this country are not prepared to offer a course in calculus at that level. Again, these courses can be principally taught by computer.

Though an NSF grant, Patrick Suppes at Stanford University has overseen the development of a computer-based advanced placement course in calculus. During the 1990-91 school term, it was piloted with very bright middle school students. During the spring of 1991 these students took the AP calculus exam. We await the results.

Adult Education/Workplace Literacy. The literacy problem facing this country for adults in and out of the workforce has been well documented. When new jobs are ranked according to the language, reading, math, and reasoning skills they require, only 20 percent fall into the lowest levels. By contrast, 41 percent of new jobs fall into the highest level of skills. (Workforce 2000).

Computer-based instruction offers hope in raising the skill levels of the unemployed and also those who are employed. With individualized lessons that are self-paced, have tailored feedback, and include evaluation of progress, these learners will in effect have personal tutors. It is especially critical to adult learners to have intelligent computer-based instruction that will be sensitive to the individual learning styles and speed of the learners. Since workers' prior knowledge is more extensive than in younger learners who may be working on comparable basic skills, it is imperative that the computer-based instructional system be sensitive to when learning takes place. Some of the sophisticated CBI programs have this capability.

CBI has been implemented in several nationally known companies. Analyses of some of these sites have shown remarkable results. For Example, Weber Metals in Los Angeles has published statistics showing the following average grade gains:

Course	# of Hours	% Gain
Math	19	19
Reading	10	37
English as a Second Language	30	22

Other companies are reporting reductions in absenteeism, an increase in production efficiency to measurable savings and general improvement in quality, and workforce attitude.

When employees need to develop new job skills or update existing skills, CBI has been a major means for employers to provide training. When used on a large scale and in geographically diverse worksites and at times convenient to the learner, the cost-effectiveness of CBI is remarkable compared to face-to-face classroom training. The CBI technology is now in place for workers to actually take the CBI at home and download the performance records to a diskette. The worker periodically brings the diskette to the training facilitator so that progress can be recorded. The worker either has a computer at home, or the workplace has microcomputers to loan to workers for a period of time.

Computer-Based Instruction -- Selected References

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President Computer Curriculum Corporation	1990 - Present
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Director of Federal Projects Jefferson School District Daly City, California	1977 - 1980
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Principal/Teacher Berkeley Unified School District Berkeley, California	1972 - 1975
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Research Assistant, Ford Foundation Project Lagos, Nigeria	1970
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Community College Supervisor Credential	1976
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With Dr. Patrick Suppes, "Possibilities for Computer Assisted Instruction," National Association of Secondary School Principals Bulletin, April, 1985.

"Computers Use in Education," California School Board Journal, Spring, 1984.

With Harriet Jones and others, "K-8 Social Studies Curriculum Guides," for the Jefferson School District and the U.S. Office of Education, June, 1977.

"Secondary School Curriculum Guides," for the Berkeley Unified School District and the National Insititute of Education.

LEADERSHIP NEWS AASA

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Districtwide technology boosts learning

Lewis Rhodes
Associate Director
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During the year AASA staff spent in Calvert County, Md., schools developing a videotape on leadership and technology, we learned that "conventional wisdom" about technology in schools may be too conventional . . . and not very wise. Too often we tend to view technology as something schools give to children for tomorrow, rather than to teachers for today.

The videotape, "Leadership & Technology: Connections for Success," and companion guide, tell the story of a 10,000-student school district that took on the task of improving an entire district's ability to respond to the learning needs of each child. The district used an Integrated Learning System (computer-assisted instruction) to teach each child every day. More than that, though, teachers and administrators could access information from student-computer interaction as often as they wanted to, in order to inform decisions about curriculum, instruction and supervision.

A number of other school districts across the country are using Integrated Learning Systems. But it is rarer to find ILS districtwide. Most often, it seems to be reserved for special populations — namely, "at-risk" students.

We first became interested in Calvert County when we heard it had moved from 14th to third among the state's school districts for reading, language and mathematics; that 92 percent of the students were scoring above the 50th percentile with virtually no one in the first three stanines. Moreover, the effects were being sustained for Chapter 1 children, and parents were withdrawing children from private schools to put them back into the public ones.

We became even more interested when we read critical reports from technology "experts" that regardless of results, whatever the county was doing wasn't a "good" use of technology. Students were in labs, using a "closed" system with a predetermined curriculum, rather than in classrooms with free-standing computers and each teacher choosing the software.

Working with Dr. Allan A. Glatthorn of East Carolina University, we made an early visit to the district to see whether we could find why such good results were coming from such "unacceptable" uses of technology. That's when the results became even more curious.

In this age of decentralization, we heard teachers and building administrators we interviewed praising their centralized, systemwide curriculum and supervisory processes. They universally attributed their successes in raising student achievement to strong central leadership. Teachers said the use of labs freed them to be more creative, rather than eroding their autonomy.

- Because of the nature of the courseware, students experienced success relatively quickly. This reduced anxiety for administrators, giving them more room to make broader modifications in schooling, while silencing potential critics. It also provided both students and teachers with a base of positive experiences to build on.
- Both principals and teachers felt confident that they could take additional risks. Since they knew "no one would fall through the cracks," they could be more creative in classroom and building problem-solving. They didn't have to spend energy reinventing curricular wheels.
- New "problems" were used as a focal point for collaboration between school buildings and the central office. For example, the district had to figure out a way to move 10th grade algebra to the sixth grade, in order to keep up with student progress.

In Calvert County, we saw threads running through the district's seven- year experience with technology:

- A constant vision was based on connected beliefs that all children can learn and all staff can be growing, creative professionals.
- The superintendent reinforced the connections among curriculum, supervision and instruction using information generated by technology.

This information, gleaned from students interacting with computers in a non-testing mode, had been unavailable to teachers and principals previously. Yet it was vital to their management of teaching and learning. Furthermore, this student-specific data was an important resource for collegial interaction among teachers and principals, who used it to focus on new ways to respond to specific needs of "their kids."

If schools want sustained high levels of student achievement, they cannot afford to continue as the only work setting that provides computers as tools for clients before workers.

Also, for districtwide improvements to be maintained, there first must be a school "system." The connecting relationships that enable parts to work together toward common purposes must be in place. The goal: to make school districts, rather than computer labs, the Integrated Learning Systems.

SPECIAL REPRINT *The Leadership News*, **December 1990**
CAI from Computer Curriculum Corporation plays a major role in this district's accelerated gains.

Computer-Assisted Instruction in Calvert County Public Schools

Five years ago Calvert County Public Schools became one of the nation's earliest large-scale users of computer-assisted instruction. In October 1983 hardware and software was installed to provide daily computer practice activities for all students in first through fifth grades in the county's six elementary schools. Dr. Eugene M. Karol, superintendent since 1980, had become convinced that computer practice activities could supplement classroom instruction to significantly improve the achievement of elementary school students in mathematics, reading and language arts.

Low student achievement had been a issue in Calvert County since 1973 when county-by-county scores were published for the new statewide standardized testing program and Calvert County ranked 23rd or 24th of the 24 school systems in Maryland. By 1979-80, the last year Iowa Tests of Basic Skills were used statewise, achievement scores in Calvert County had already risen substantially to at least the state average in third and fifth grade, as displayed in Table I.

Table I
Achievement Test Scores
Iowa Test of Basic Skills (Grade Equivalent Form)
Maryland and Calvert County
1973-74 and 1979-80

	Third Grade			Fifth Grade			Seventh Grade		
	Read. Comp.	Lang. Total	Math. Total	Read. Comp.	Lang. Total	Math. Total	Read. Comp.	Lang. Total	Math. Total
1973-74									
Maryland Average	3.6	3.9	3.6	5.3	5.5	5.5	6.9	7.1	7.2
Calvert County	3.0	3.4	3.1	4.4	4.6	4.7	6.0	5.7	6.1
Position in State	23	23	23	23	24	24	23	24	24
1979-80									
Maryland Average	3.9	-	-	5.6	6.1	5.8	7.0	7.4	7.4
Calvert County	4.0	-	-	5.6	6.5	5.8	6.9	7.4	7.0
Position in State	9	-	-	15	6	8	17	10	19

The improvement in test scores during the decade of the seventies came at a time when the population of Calvert County and the public school enrollment were increasing. The growth has continued into the decade of the eighties, as displayed Table II.

Table II
Population and School Enrollment
Calvert County

	Population	Public School Enrollment
1970	20,942	5,891
1974	25,119	6,832
1978	31,678	7,722
1982	36,600	7,781
1986	43,700	8,499

Calvert County had been a area where most families derived livelihoods from tobacco farming, other farming and fishing. Much of the population increase represented persons moving into the county who were employed in the county's businesses and retail trades or commuted to Washington-area government and services employers. With an increasingly middle-class student population, there was an increase in the average intellectual ability of Calvert County students as measured by the Cognitive Abilities Test administered during the first five years of the statewide testing program. Calvert County's achievement scores to at least the state average occurred in third and fifth grades at the same time that average intellectual ability increased somewhat but still remained under the state average, as displayed in Table III.

Table III
Ability Test Scores
Cognitive Abilities Test, Non Verbal 1971 (Standard Age Scores)
Maryland and Calvert County

	1973-1974		1975-1976		1977-1978	
	State	Calvert County	State	Calvert County	State	Calvert County
Third Grade	100	92	102	95	104	98
Fifth Grade	101	93	103	99	106	103
Seventh Grade	101	91	103	95	104	103

A more important factor related to the achievement score increase during the decade of the seventies were the efforts of Superintendent Ralph Wachter to improve instruction in Calvert County's elementary schools. Mr. Wachter emphasized a strong reading program including the development of a county-wide reading curriculum based on two textbooks -- the Harcourt series and the McMillan series. He concentrated resources on the first three years of elementary school, developed remedial mathematics and reading programs with attention to early remediation, instituted more frequent to evaluations of teachers and administrators, and increased staff development activities.

Dr. Eugene M. Karol became superintendent during the 1980-81 school year. He intensified the emphasis on county-wide reading and mathematics curricula and added teacher-based instructional management systems in both areas. The Addison-Wesley mathematics series, the Ginn reading series for below and on-grade students, and the Scott-Foresman reading series for above-grade students were chosen, in part for the record-keeping systems based on unit pretests and posttests that accompanied the textbooks. Chapter 1 students continued to receive additional instruction in reading and mathematics using the Random House Hils Reading and Mathematics program materials. Dr. Karol also provided for careful monitoring of the teaching process through implementation of the Glatthorn Supervisory Model in 1983-84.

Dr. Karol looked to computer-assisted instruction as another means of improving student achievement. After an extensive study of available programs, Dr. Karol selected the Computer Curriculum Corporation's (CCC) integrated learning system noting that "We planned, looked around, asked questions and decided on CCC because it fit our curriculum and we saw phenomenal results in schools where it has been used."

Curriculum-fit attributes include CCC's correlation with the textbooks in use countywide as well as the California Achievement Tests (CAT), the standardized achievement test used in the statewide testing program since 1980-81. The California Achievement Test is administered to Maryland students in third, fifth and eighth grades and to all Calvert County students in every grade. Other attractive aspects of the CCC software include its initial testing and placement of each student in exercises within a sequence that matched the student's previous achievement, its provisions for teacher selection of either "mixed drill" or "fixed drill" options, and its progressively challenging exercises within a sequential curriculum. Also important is the provision for management reports for teachers on student and group progress.

CCC equipment in Calvert County consists of two mini-computers or central processing units, student terminals, printers and the software. The central processing units were installed at Mt. Harmony and Mutual Elementary Schools. The unit at Mt. Harmony drives terminals at Mt. Harmony, Huntington and Beach Elementary Schools. The unit at Mutual drives terminals at Mutual, Calvert and Appeal Elementary Schools. The schools are connected to the central processing units by telephone lines and the software and all student records are stored in the central processing units.

Each school has 28 or 29 terminals in its computer laboratory which is staffed with a computer laboratory aide. Since the advent of computer-assisted instruction five years ago, all students have gone into a computer laboratory daily. First through fifth graders spend 10 minutes on mathematics activities and some third graders and all fourth and fifth graders spend an additional ten minutes on reading and language arts activities. An aspect of the Calvert County computer-assisted instruction program is that each student spends time in computer practice activities daily.

Computer laboratory aides are an important component of the computer-assisted instruction program in Calvert County. The aides are responsible for the operation of the computer equipment including registration of students in the system, minor maintenance activities, some assistance to students at work at the computers, and generation of reports. It is estimated that about 18 students use each student workstation daily. According to Assistant Superintendent of Schools Dr. Eugene Uhlan, the computer laboratory aides "free the teachers to be professionals, not mechanics."

Hardware was purchased outright, and maintenance fees, courseware rental and telecommunication charges are paid annually. The cost of computer hardware, software and telecommunications for the six Calvert County elementary schools is displayed in Table IV.

Table IV
Computer-Assisted Instruction Costs for Hardware and Software in Calvert County Elementary Schools

School Year	Hardware and Installation	Hardware Maintenance	Courseware Rental	Tele-communication Charges	Total
1983-84	$581,404	$78,702	$58,325	$25,924	$ 744,355
1984-85	-	82,468	47,500	25,924	155,892
1985-86	-	84,015	42,093	25,924	152,032
1986-87	4,040	74,161	61,996	15,360	155,557
1987-88	-	76,880	69,600	15,360	161,840

					$1,369,676

The average annual equipment cost of the CCC system including hardware has been $1660 per work station and $93 per student, based on an average annual enrollment of 2918 in grades one through five. The average annual cost including aides has been $2200 per work station, and $125 per student. As hardware is amortized over a longer period, the annual per work station and per student costs will drop somewhat.

About a year after the Calvert County computer-assisted instruction program was in place in the six elementary schools, the program was expanded to serve middle school, special education and vocational education students. Each sixth, seventh and eight-grade student spends ten minutes daily at a terminal working on language arts software, and all except algebra students spend an additional ten minutes daily on mathematics software.

Two impressive measure of the effectiveness of computer-assisted instruction in Calvert County are available. The first measure compares the California Achievement Test scores in Calvert County of 1982-83, one year before the implementation of the program, with CAT scores in 1986-1987, three years after the program was in place. CAT scores for 1980-81 through 1986-87 are displayed in Appendix Table I; CAT scores for 1982-83 and 1986-87 as displayed in Table V.

Table V
Achievement Test Scores
California Achievement Test (Grade Equivalent Scores)
Maryland and Calvert County
1982-83 and 1986-87

	Third-Grade		Fifth-Grade		Eighth-Grade	
	Reading Comp.	Math Total	Reading Comp.	Math Total	Reading Comp.	Math Total
1982-83						
Calvert County	3.6	3.3	6.0	5.4	8.9	8.3
Maryland Average	3.5	3.4	5.7	5.6	9.3	9.0
Position in State	8	13	8	13	13	18
1986-87						
Calvert County	4.0	4.0	6.9	6.7	10.9	10.0
Maryland Average	3.7	3.5	6.1	6.0	10.0	9.8
Position in State	3	1	3	2	3	3

A statewide increase in average achievement test scores since the initiation of the statewide testing program in 1973-74 is apparent from both Table I and Table V, although the change in standardized tests makes comparisons over the entire 13-year program inexact. Publicizing county achievement test scores has focused resources on the improvement of test scores throughout the state, presumably through attention to instruction for tested subject areas.

During a period when average CAT scores in Maryland were increasing, Calvert County scores rose even more. In 1982-83 Calvert County reading scores for third and fifth graders were above the state average, but mathematics scores were still low, and both reading and mathematics scores for eighth graders were low. Four years later all scores were well above the state average. The continuing improvement in third-grade reading scores can not be ascribed to computer practice because third graders were just beginning reading comprehension computer practice at the time the California Achievement Tests was given. However, the marked improvement in the third-grade mathematics score to the highest score for a Maryland school system undoubted reflected the students' two years of daily experience with mathematics computer practice by the time they were tested as third graders.

The 1986-87 fifth-grade reading comprehension scores reflected daily experience with reading comprehension CAI in fourth grade, and the eighth-grade reading comprehension scores reflected daily experience with reading comprehension CAI in fifth, sixth and seventh grades. Both scores showed substantial improvement, and both scores ranked third in Maryland. 1987-87 fifth-grade mathematics scores reflected experience with mathematics CAI in second, third and fourth grades; this score ranked second in Maryland. The eighth-grade mathematics scores reflected experience with mathematics CAI in fifth, sixth, and seventh grades; this score ranked third in Maryland.

A second measure of the effectiveness of the computer-assisted instruction program in Calvert County was assessed in a study conducted by Dr. Gilbert R. Austin, Director of the Center for Educational Research and Development, University of Maryland Baltimore County. Austin's study compared the achievement test scores of students in the two years prior to the computer-assisted instruction program with their scores in the first three years of to the program.

Austin tracked two cohort groups of students who were second or third graders in 1982-83 for whom five sets of California Test data were available through 1986-87; initially both groups had about 550 students. Over the five-year period of the study, each group lost about 200 of its members since students for whom any yearly data was missing were dropped from the study. For each student, the average of his or her Standard Age Scores for the two years Before CAI was compared with the average Standard Age Score for the three years Since CAI. The results are displayed in Table VI.

Table VI
Achievement Test Scores
California Achievement Test (Total Battery Standard Age Scores)
Calvert County Public Schools
Before CAI, 1982-83 to 1963-84; Since CAI, 1984-85 to 1986-87

	Total Cohort Group	Black Students	Chapter I Students
Cohort I			
Number of Students	344	89	31
Before CAI/Grades 3, 4	63.7	55.8	43.1
Since CAI/Grades 5, 6, 7	66.9	60.0	47.8
Cohort II			
Number of Students	309	79	63
Before CAI/Grades 2, 3	59.3	50.1	37.7
Since CAI/Grades 4, 5, 6	66.8	57.7	50.7

The Before CAI scores for Cohort I with 344 students were an average of each student's third and fourth-grade CAI Standard Age Scores (a percentile form of the scores) and the Since CAI scores were an average of fifth, sixth and seventh-grade scores. The Before CAI mean score on the Total Battery of the California Achievement Test for Cohort I was at the 64th percentile, while the Since CAI mean score was at the 67th percentile, a difference of three percentile points. The Reading Battery difference was seven points, the Language Battery difference was six points and the Mathematics Battery difference was seven points (not displayed). For the cohort's subgroup of 89 black students, the Total Battery difference was four points, from 56th to 60 percentile. For the subgroup of 31 Chapter I students, the Total Battery difference was five points, from 43rd to 48th percentile.

The Before CAI scores for Cohort II with 309 students were an average of the second and third-grade scores while Since CAI scores were an average of the fourth, fifth and sixth-grade scores. The Before CAI mean score on the Total Battery was at the 59th percentile, while the Since CAI mean score was at the 67th percentile, a difference of eight percentile points. The Reading Battery difference was six points, the Language Battery difference was six points and the Mathematics Battery difference was seven points (not displayed). For a subgroup of 79 black students, the Total Battery difference was eight points, from 50 to 58th percentile. For the subgroup of 63 Chapter I students, the Total Battery difference was 13 points, from 37th to 50th percentile.

Of particular interest is the performance of the tenth and twenty-fifth percentile Calvert County students of both cohorts. Both the initial relatively high level of the lower percentile students and the improvement attributable to computer practice is evident, as displayed in Table VII.

Table VII
California Achievement Test
Total Battery National Percentile Equivalents
for Students of Selected Calvert County Percentile Rankings
Before CAI, 1982-83 to 1983-84; Since CAI, 1984-85 to 1986-87

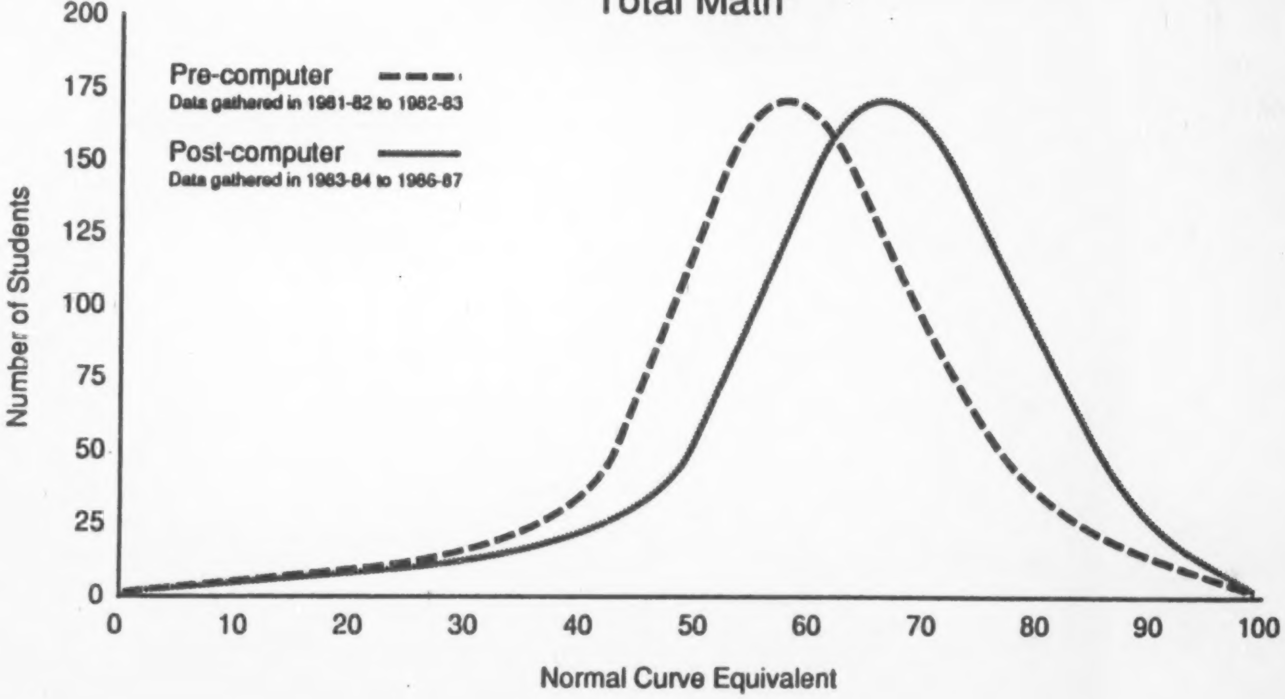
	Tenth Percentile	Twenty-fifth Percentile	Seventy-fifth Percentile	Ninetieth Percentile
Cohort I - All students				
Before CAI/Grades 3, 4	44	51	75	90
Since CAI/Grades 5, 6, 7	46	53	81	92
Cohort I - Black Students				
Before CAI/Grades 3, 4	39	46	62	80
Since CAI/Grades 5, 6, 7	42	48	69	81
Cohort I - Chapter I Students				
Before CAI/Grades 3, 4	31	40	47	50
After CAI/Grades 5, 6, 7	38	42	52	54
Cohort II - All students				
Before CAI/Grades 2, 3	36	43	74	85
Since CAI/Grades 4, 5, 6	44	52	81	93
Cohort II - Black Students				
Before CAI/Grades 2, 3	32	37	59	76
Since CAI/Grades 4, 5, 6	39	48	67	80
Cohort II - Chapter I Students				
Before CAI/Grades 2, 3	24	33	42	49
Since CAI/Grades 4, 5, 6	40	44	56	63

The accomplishments of Calvert County Public Schools in raising student achievement as measured by standardized test scores and in maintaining the increase over the three years of the computer-assisted instruction program reviewed in this document are notable. Sustained results of this magnitude can be attributed to strong school system leadership, close supervision of the teaching process in mathematics and reading, and daily supplementation of classroom instruction with computer practice activities.

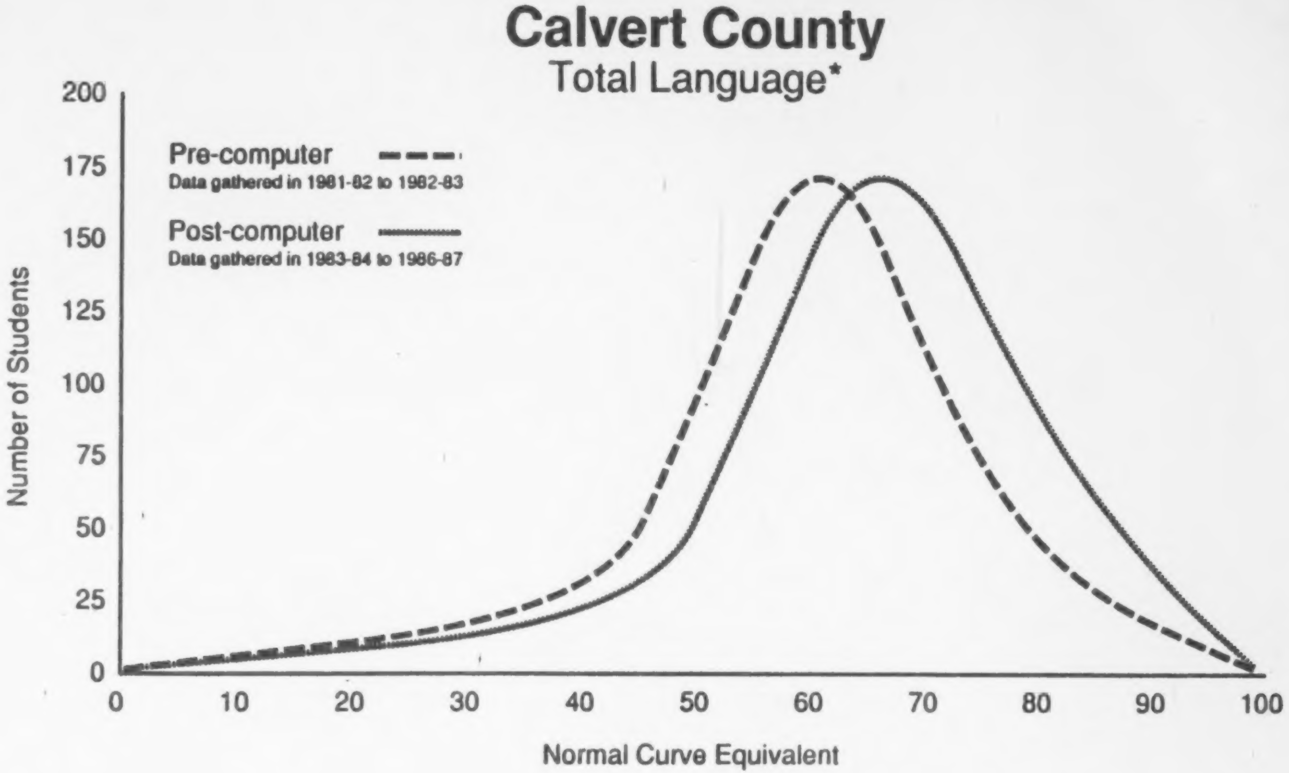
Appendix Table I
Achievement Test Scores
California Achievement Test (Grade Equivalent Form)
Maryland and Calvert County
1980-81 through 1986-87

	Third Grade			Fifth Grade			Eighth Grade		
	Read. Comp.	Lang. Total	Math. Total	Read. Comp.	Lang. Total	Math. Total	Read. Comp.	Lang. Total	Math. Total
1980-81									
Maryland Average	3.0	3.3	3.3	5.5	6.0	5.3	8.6	8.6	8.6
Calvert County	3.5	3.6	3.3	6.0	6.5	5.6	8.1	8.5	8.1
Position in State	9	9	8	6	8	8	20	15	18
1981-82									
Maryland Average	3.4	3.6	3.3	5.8	6.8	5.5	9.3	9.2	9.0
Calvert County	3.6	3.6	3.3	5.9	6.5	5.4	8.9	9.4	8.3
Position in State	6	11	9	11	9	13	11	9	16
1982-83									
Maryland Average	3.5	3.7	3.4	5.7	6.6	5.6	9.3	9.2	9.0
Calvert County	3.6	3.6	3.3	6.0	6.6	5.4	8.9	9.4	8.3
Position in State	8	14	13	8	10	13	13	10	18
1983-84									
Maryland Average	3.5	3.7	3.4	5.9	6.7	5.7	9.7	9.7	9.2
Calvert County	3.7	4.2	3.6	6.6	7.9	6.4	10.0	10.5	9.0
Position in State	8	4	3	3	3	4	5	3	9
1984-85									
Maryland Average	3.6	3.8	3.5	6.0	7.0	5.9	9.8	9.8	9.3
Calvert County	3.8	4.3	3.9	6.9	8.2	6.7	10.0	10.6	9.1
Position in State	7	3	2	3	3	2	7	4	9
1985-86									
Maryland Average	3.6	3.8	3.5	6.1	7.1	5.9	9.8	10.0	9.5
Calvert County	4.0	4.4	3.9	6.6	8.1	6.6	10.3	10.7	9.2
Position in State	3	4	2	4	3	3	4	3	11
1986-87									
Maryland Average	3.7	3.8	3.5	6.1	7.3	6.0	10.0	10.2	9.8
Calvert County	4.0	4.5	4.0	6.9	8.4	6.7	10.9	11.8	10.0
Position in State	3	3	1	3	3	2	3	1	3

Calvert County
Total Math*

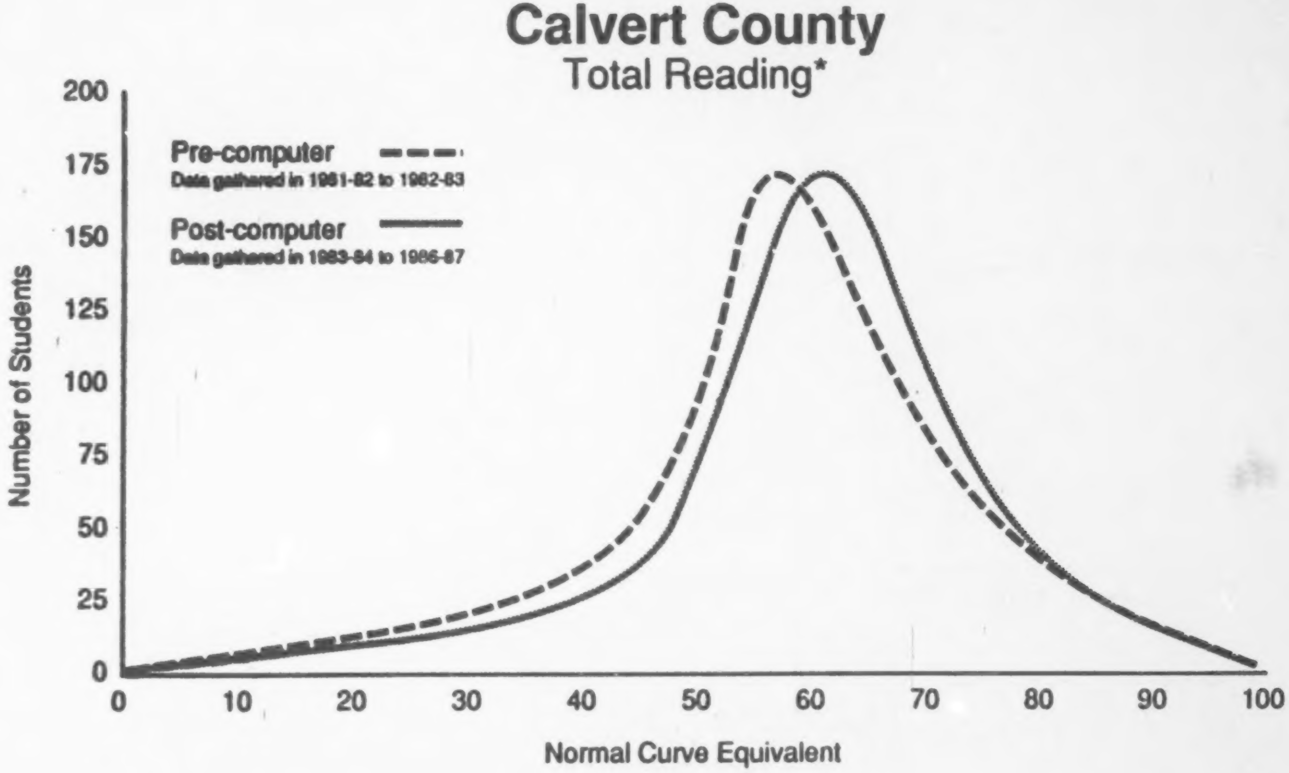


Total number of students in the population equals 344.
*Cal. Ach. Test Form C, 1978



Calvert County
Total Language*

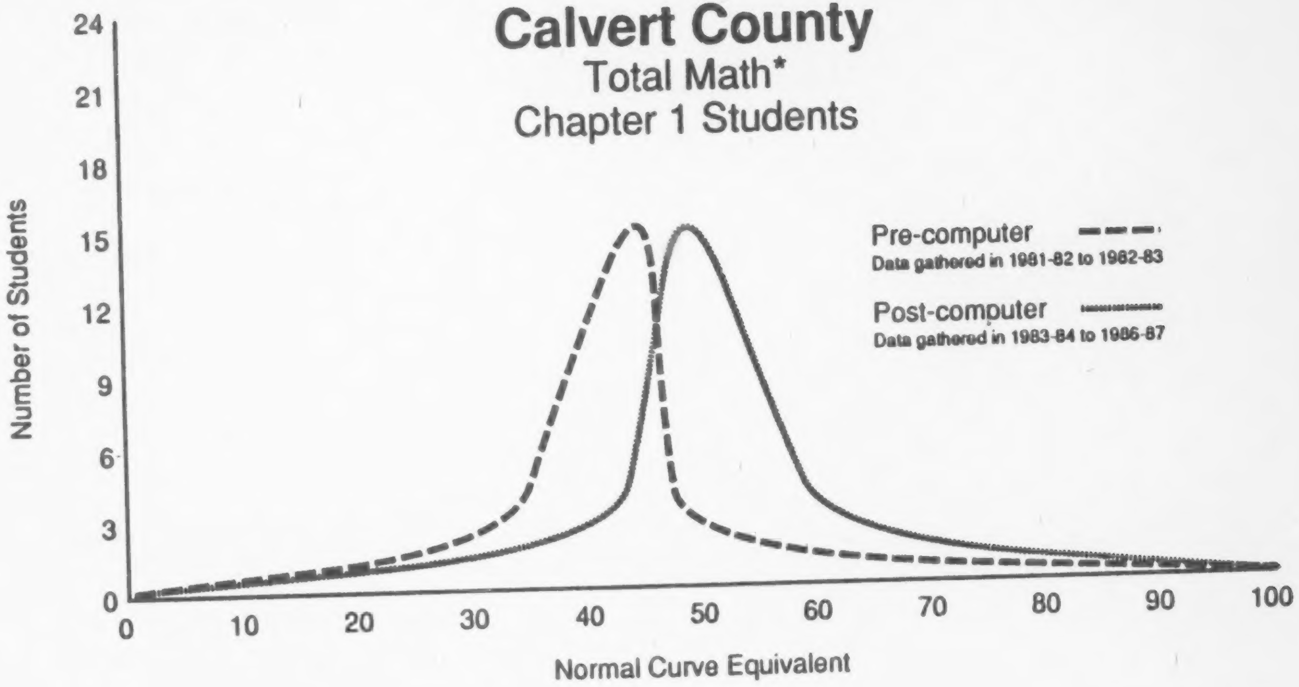
Total number of students in the population equals 344.
*Cal. Ach. Test Form C, 1978



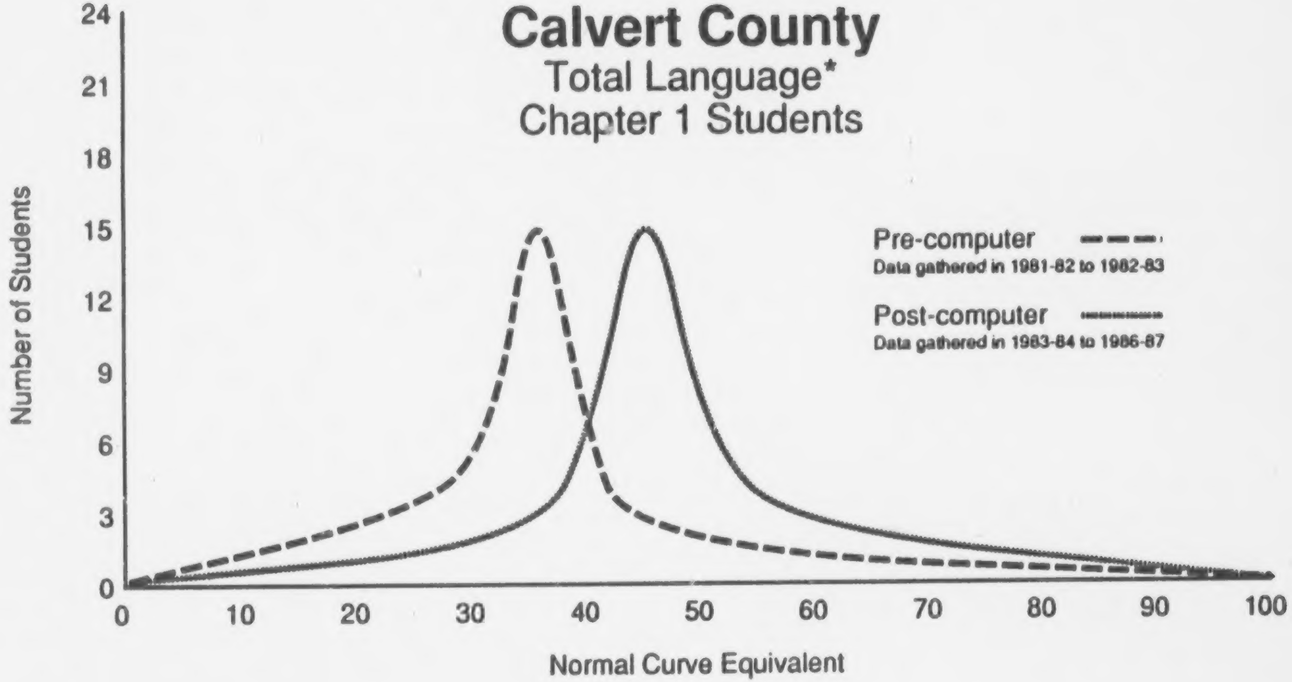
Calvert County
Total Reading*

Total number of students in the population equals 344.
*Cal. Ach. Test Form C, 1978

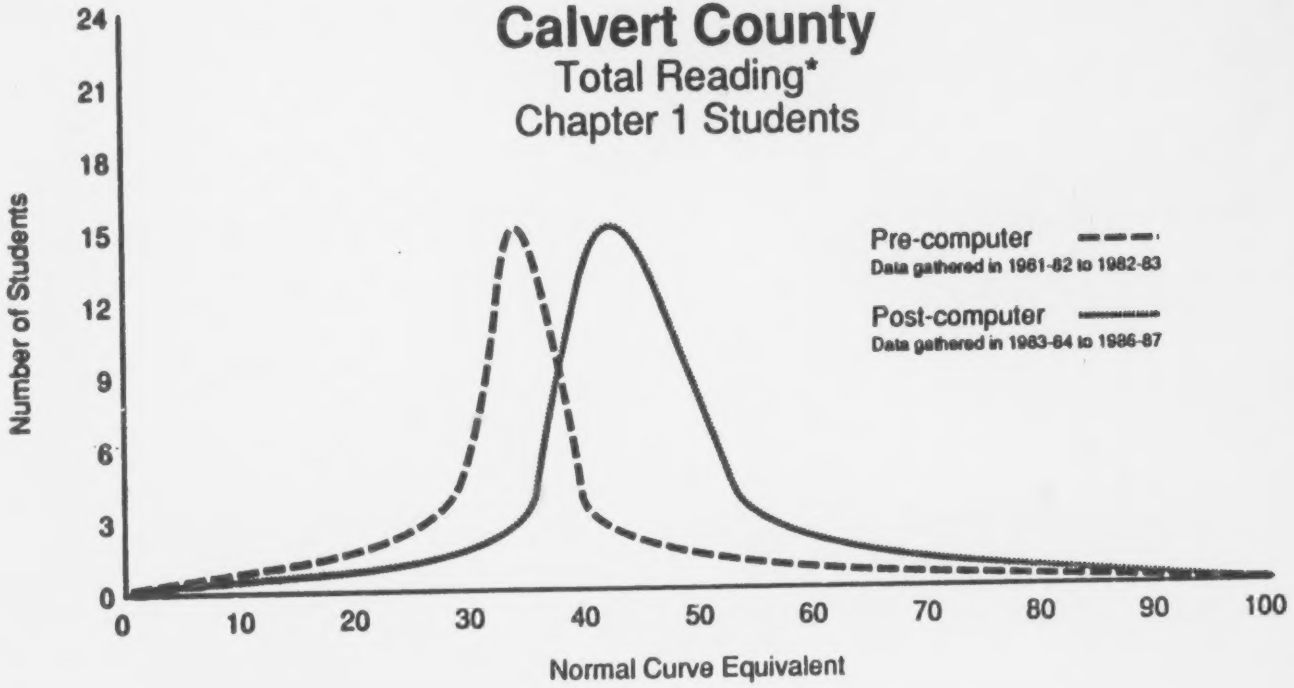
Calvert County
Total Math*
Chapter 1 Students



Total number of students in the population equals 31.
*Cal. Ach. Test Form C, 1978



Total number of students in the population equals 31.
*Cal. Ach. Test Form C, 1978



Total number of students in the population equals 31.
*Cal. Ach. Test Form C, 1978

Mr. **Swett**. Thank you very much, Dr. Fortune.

We will now proceed with Mr. Albert Shanker, President of the American Federation of Teachers, who is going to present the teachers viewpoint.

Mr. **Shanker**. Mr. Chairman, Members of the committee, I've submitted written testimony and I'll use these few minutes to make several points.

I think that the—if we look at the results that we're getting from our educational system, just a little bit of analysis, will lead us to the conclusion that—that the fact that we have a growing availability of technology is important and, indeed, it's absolutely necessary to change the results that we're getting.

I—we're fortunate to have people like David Kearns—I agree with everything he said except one thing; I'll start with that. As he said, we're providing a good education for the top half.

I wish that were so. But if you look at last week's math results, for instance, and you look at the percentage of 17-year-old youngsters who reach the 350 level in mathematics, those are the only ones who are really capable of going on, ready to do college level math as they graduate high school.

Five percent of the public school graduates reach 350, four percent of the Catholic schools and 4 percent of the other private schools. So basically, public, Catholic, private, all producing about the same percentage—four or five percent of the youngsters who can go on.

Now essentially this means that—that the overwhelming majority of our kids who go on to college are mathematically illiterate. It means that, for instance, Germany, which sends 30 percent—in Germany, you can't get, no one can get into a college or university without passing the arbiter in mathematics, which means that you've got 30 percent of the youngsters who reach a level that is equal to or higher than our top five percent. Well, so it's not the top half that we're doing well with, it's maybe about a top three or five percent.

And while we are spending more—a greater percentage of our GNP on education, the higher education that we're spending it on, we're really basically buying a junior high school and high school education for huge numbers of kids and calling it a college education. A very ineffective way.

Now, it seems to me that the rationale for increasing use of technology is—is very simple. We know that large numbers of youngsters can't sit still all day long; and those who can't are generally viewed as being handicapped in some way and are given a very tough time.

Large numbers of kids cannot learn in the one way that they're compelled to learn, namely, listening to somebody talk all day long. And those who can listen to someone talk can't necessarily receive it at the rate it's being sent.

There are some who are bored to death in that class and some who are for whom the teacher is going so quickly that they can't get it. So you've got a standardized conforming sort of thing where a lot of kids drop by the wayside.

And then you've got other problems the kids have, namely, in order to be successful a kid has to survive in a class where periodically the youngster is called, and if they can't answer the question they have to survive that public humiliation in front of all their peers.

And kids also know in September that the final report doesn't come until the following June, so you have to have kids who've got the—the ability to know that what they do on September 4th is important, September 5th, and September 6th, and September 7th.

Most adults, if you told them they had to do something today because something is due next June—so what I'm saying essentially is that the consequences of one's behavior are so delayed that it's not surprising that a large number of youngsters fall back.

Add to this one other item, and that is that that five percent that I gave you on mathematics is also true in reading, it's also true in writing, it's also true in science, and it's also true in social studies, which essentially means that if only five percent of our youngsters are leaving high school to enter college, there's no way that 23 percent of the college graduates who have to become teachers are going to be adequate teachers.

Now, all this, it seems to me, argues for some sort of a system which enables kids to learn in the time that it takes them to learn; to provide alternatives through the talk of one individual, namely, the teacher in school; to provide greater privacy, which takes you away from the humiliation so that if you don't make it and fail, nobody else is watching you or seeing use of it. You're not discouraged.

And not as a replacement for teachers, but if you don't have—essentially what these figures show is that if we put a teacher in each of 2.5 million classrooms, we're bound to have huge numbers of people who should not be teachers locked in those classrooms with kids.

And—and in any other field of work, if you could not find an adequate supply of people who are competent to do the job, you would look for other ways to do it, and you would look at least for some technology component in doing that.

Now what—I—I would just like to address the question of—of why we're not using more of it, and I'd also like to address the question of why, when we use it, we generally use it in very ineffective ways.

I think that the issue that we've got here is the fact that essentially we do not have a system of incentives built into our school system for success, nor a system of negative incentives or punishments for failure.

I don't think you'd see technology used in business today if there were not consequences for not using it. I mean, it's used because firms have to use it, and if they don't use they'll be out of business because somebody else is, and it's going to do things more efficiently, and do it better; whereas, we don't have that system in education.

Now that's true for both the adults and for the youngsters. You can have all the technology in the world and not many more kids are going to learn math if you can get into college in the United States without knowing any.

How—what would happen to our system if we told all the people who work for a living in this country that they would be paid and get all the perks of the job if they didn't show for work—that showing up for work became voluntary?

Well, essentially, that's what we tell kids when we say that, you can get what you want to get, namely, enter into college, even if you can't read, you can't write, and you can't do mathematics.

So essentially, the tech—we first need a system of incentives, both for the adults in the system and for the youngsters. And if you have a system of incentives, then you can trust the people within the system to find efficient ways for reaching the goals that they want to reach. And that's why I would favor the notion that we not mandate or legislate specific use of technology.

I think that if there were rewards and punishments for doing things right, that people would be out there eagerly trying to figure out what technologies they need; they would be trying it, they would be testing it; and they would be doing something that's more important, and that is constantly trying to make it work better for them.

Technology is not something you just plug in and it does it for you. You've got to have it work for you and the incentive systems are essentially the—the thing that would make the whole thing work.

Thank you.

[The prepared statement of Mr. Shanker follows:]

TESTIMONY OF ALBERT SHANKER
PRESIDENT, AMERICAN FEDERATION OF TEACHERS
BEFORE THE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY'S
SUBCOMMITTEE ON TECHNOLOGY AND COMPETITIVENESS
JUNE 18, 1991
U.S. HOUSE OF REPRESENTATIVES

On behalf of the 750,000-members of the American Federation of Teachers/AFL-CIO, I would like to thank Chairman Valentine and members of the committee for the opportunity to appear here today and talk about the role technology can play in our efforts to improve public education in this country.

We don't have to look hard to see the impact technology can have. In business, there has never been an increase in productivity in this country without a change in technology. Telephones. FAX machines. Computers. All have revolutionized the way we do business by increasing the productivity of workers by allowing them to work differently and more efficiently.

But there is one thing we can learn from the spread of technology in other fields; it only works when people recognize the need for it and use it to operate differently from the way they have in the past. There have been studies done of the work of bank tellers and claims adjusters that demonstrate how their job responsibilities and capacities have changed and expanded because of technology.

Things are no different in our schools. Technology can help us change the structure of schools and give us new resources to approach teaching and learning. Technology can help teachers set up classrooms where individualized and small-group learning can predominate. Technology can help teachers communicate with each other. And technology can help us meet the current shortage of math and science teachers.

Before addressing the potential technology has in these areas, a warning is needed. Although technology can and should be integrated into our overall efforts to improve public education, we need to be aware of some dangers. Unless we employ technology in new ways, it will just be used to do the same stuff we know doesn't work. For example, making students sit still and watch a video of a lesson is no better than having them sit still and listen to a teacher (it may be worse). And having them fill in the blanks in a computer exercise is no better than having them fill in the blanks on a worksheet. We need to use the machinery to do new things, to restructure the classroom to best meet students' needs. If we don't take these steps, technology will have a minimal impact on our students' performances.

Keeping that caution in mind, let's look at how technology can help. The open classroom of the 1970s failed because teachers did not have the resources to maintain a classroom where kids learn in small groups and where every child needed to come up with enough activities to keep each student engaged and out of trouble.

But now, with the new technology that is available, it is going to be possible for teachers to customize education for different students and groups of students. Teachers will no longer have to deliver all the content of a course through traditional lessons because they'll now have thousands of video and audio tapes, simulation games, models and computer programs that will allow students' lessons to be tailored to their needs. Kids can watch them individually or in small groups. They can even take tapes home. Technology makes it possible to offer kids the materials they need in the forms that are appropriate for their needs.

Let's take a history class. Instead of lecturing about Grant's role in the Civil War, the teacher might suggest that Johnny watch the recent PBS documentary on videotape, replaying the parts he didn't get. At the same time, Mary, who connects better with the printed word, could work with a data-base to track down articles that supplement class discussions. Another student, Carlos, who has a hard time understanding Grant's battle strategies, could be helped to visualize the battles by action maps the teacher called up on the computer. So far, the problem with much of the educational technology that has been introduced into schools is that we haven't used it to do anything different.

Technology can also be used to help us meet the teaching shortage, particularly in the areas of math and science. Right now, we don't have enough teachers who can successfully teach math and science. Retraining and recruiting teachers will take time and cost money; there are no shortcuts and we aren't about to get new, qualified teachers because there are not very many in the pipeline. But between now and the time we get them, technology can help.

Teachers can be supported in their efforts to upgrade their students' achievements in mathematics and other fields by allowing them to incorporate challenging software programs, interdisciplinary multimedia programs, interactive distance learning and other similar activities into their everyday experience.

Technology gives us the tools to allow students to learn at their own rates and in their own ways--tools that free up teachers so they can teach in new ways. This time, let's take mathematics and science classes using a wonderful program developed by Bank Street College in New York called the "Voyage of the Mimi." It is a 13-part television drama portraying a group of young scientists as they study the habits of whales off the New England coast. Different computer modules are attached to each of the episodes allowing the children not only to simulate the experience of the scientists, but actually to do science and math activities such as measuring light, sound and temperature readings. Using computers in this way goes far beyond the confines of traditional graph paper and thermometers. Organizing the complex and varied materials this series offers is the responsibility of the teacher, but much of the richness of the program is really due to the technology.

Technology can also help teachers keep on top of all the new information that's out there. There are so many technological alternatives out there, it's often hard to tell what's junk and what's valuable. Right now, almost every field has a national data base. Why not create one for teachers? Such a data base could list the materials and the technology available to help kids learn about the Civil War or about mathematics. And besides videotapes and computer programs, the data base could also list charts, chapters of books, games and models that could be made by teachers or students. The materials would be verified by brief reviews from peer-review panels of outstanding teachers in each field.

If the technology is to be adopted it must meet a need. In business, this might mean becoming more productive in such a way that market share and profits eventually increase. In schools, it must mean that we see improvement in student outcomes. But if no consequences result from not achieving improved outcomes, using technology effectively will never be a high priority. Why spend money and time trying to incorporate technology if there are no rewards for success. We need incentives in schools just as we need incentives in business. Without them, outcomes and goals will remain abstractions.

Clearly, using technology in this way goes beyond substituting a videotape for the teacher. It requires the teacher and the technology to be related. As valuable as technology can be, it won't make a difference unless we offer teachers and other professionals who work in our schools opportunities to use it in new ways. We will need to demonstrate that changing the practices and routines that have been part of their professional lives for years will be an important part of improving their students' performance.

To do this, I propose that an incentive program be established to encourage improvement in the public education system. We should establish a voluntary, nationwide, multi-year competition open to every public school in the United States. The winners could be the 10 percent of participating schools that achieved the greatest improvement over the time of the competition, which might be five years. The prize would be the money--generated by a national trust fund--to be divided among the staff members of the winning schools. If every school in the country volunteered to compete we should invest enough money so that the winners would receive about $16,000 for each staff member in the winning schools. That's real money, and, since one in 10 schools would win, that's a real incentive to participate.

The object of such a plan is not to reward schools that are already on top, but to reward improvement. A school whose students start at the bottom and bring their achievement levels up could win, while a school at the top--whose students have ususally performed well--would not if they haven't demonstrated improvement. If we provide each and every public school participating in this Incentive School Plan the computers, software, videodiscs and tapes they need during such a competition, and free participating schools to develop new ideas and try new practices, imagine how technology could be used. The examples I illustrated earlier are just the tip of the iceberg. The Saturn school that President Bush points to so proudly (which was developed in large part through the effort and support of the St. Paul Federation of Teachers) could be just one of a hundred schools to use technology in new and innovative ways.

This incentive proposal is just a beginning. There are other ways to motivate people to incorporate technology that could help both educators and students. We won the war in the Persian Gulf by using technology to its fullest potential. It didn't replace soldiers or military strategy; it enhanced both. We need to devote the same type of resources to determining the best way to use technology in our public schools.

Mr. **Swett**. Thank you very much, Mr. Shanker.

At this time, I understand that Congressman Ritter would like to make a brief—a few brief remarks regarding one of his constituents on the panel.

Mr. **Ritter**. Thanks, Mr. Chairman.

I'm in the position of having a very important meeting coming right up and thought we might have gotten through to date, but to this moment we haven't.

I'd like to introduce Dr. Leroy Tuscher, who holds a joint appointment as a professor in both the Department of Leadership Instruction and Technology in the Department of Computer Science in Electrical Engineering at Lehigh University.

He also serves as the Director of the Educational Technology Center. He has been actively involved in applying leading edge technology in the design and development with the Intellectual Work Environment for Teaching and Learning, and has directed numerous research projects involving interactive multimedia learning technologies ; and he's currently managing projects to design and construct a teleconferencing classroom that can be used to provide instructional programs to corporations and schools.

This is part and parcel of a very extensive business education partnership that's occurring in the Lehigh Valley, and David Kearns mentioned it—Donnelly, Lee Iacocca's—Iacocca Institute is involved in this, and to some extent, Lehigh University is—and our community is leading America.

He has also an extensive background as a professional educator, and prior to his current position he has taught high school math and been employed as a high school principal.

May I ask, Mr. Chairman, unanimous consent, perhaps, that Dr. Tuscher could testify—

Mr. **Swett**. I was going to allow him to follow—

Mr. **Ritter**. That's great, thank you.

Mr. **Swett**. Such a glowing introduction, we should proceed with that order.

Mr. **Ritter**. Thanks, Mr. Chairman, I really appreciate that.

Mr. **Swett**. Please, the microphone is yours.

Mr. **Tuscher**. Thank you, Mr. Chairman.

It's my pleasure to be able to testify before this distinguished group of representatives today.

My topic for presentation is listed as interactive video disc technologies. I'm going to take somewhat of a circuitous route to the discussion of that technology because I believe there are important elements that need to be discussed relative to that technology.

Mr. **Ritter**. Excuse me, Dr. Tuscher, could you please pull the microphone towards you and speak a couple of inches from it.

Dr. **Tuscher**. I'm sorry, is that better?

Perhaps history has a lesson to be learned about improving a learning productivity in schools. "Analysis of the Factors Related to Improved Productivity in the Workplace," by Peter Drucker, identified three prime factors responsible for increased productivity in the workplace as our society moved from an agrarian to an industrial economy.

These three factors were: heavy capital investment; improved management techniques, and technology itself.

They make me—make an analogy between that transition period and the period of transition—we're talking about in terms of learning productivity; certainly are going to need some heavy capital investment to break the mold, as discussed by Mr. Kearns and Dr. Massey.

That investment will be not in the so-called "dumb machines"—the mechanical machines—they will be in the smart machines.

We'll need to see improved management techniques based on production output, as on outcome based learning systems which will drive that learning productivity.

As respects the technology indicated, they will move from the mechanical to the electronic. Of course, the mechanical empowered us physically; the electronic technologies, we will hope, empower the intellect.

Perhaps maybe the new American schools, network of pilot schools, discussed today and originally announced by President Bush, will provide the capital incentive necessary for restructuring American schools for productive learning.

Secondly, improving the learning productivity will require improved management techniques in guiding the teaching learning process.

For example, if for purposes of discussion here today, we described the teaching act as consisting of performance of three primary functions, that is, delivery, that is the classroom presentation; management, that is managing the mix of learning resources and; thirdly, production, that is delivery management and production.

Studies by Glaser and Goodlad have confirmed that the time distribution among these three functions is pretty much constant. But the greatest percentage of time, perhaps, 70 percent or more devoted to that function of delivering instruction and is primarily that didatic mode, that is, the teacher talk.

This distribution of time in the classroom, as I said, is essentially constant from classroom to classroom, school to school, and district to district, across the United States.

Essentially it leaves very few degrees of freedom for improving learning productivity. What is needed is some experimentation with the redistribution of teacher time in the teaching learning process directed toward outcome based instruction.

The technology, the third component. The technologies offering the greatest potential for improved learning productivity are both product and process. Product, in terms of communications technology and information processing technologies. Process having to do with the educational technologies, the mixing of the resources from proving learning outcomes.

The communication technologies , as stated earlier many times today, provide the pathways to knowledge, the electronic highways for accessing information. The means provides—the means for the digital transmission—and I emphasize digital because that is an important component of my concluding remarks—as the means for the digital transmission of all media formats, that is in text, graphics, animation, still photos, sound, music, and most recently, motion video; while information processing technologies provide the means by which the intellect perceives and processes that information along the network.

Respecting the educational process technologies. The successful integration of interactive digital technologies in the school practice can be obtained by focusing attention on those variables most closely related to learning outcomes; that has to do with curriculum, instruction, and evaluation and assessment.

Curriculum, of course, is what is taught—content and the outcomes. Instruction is how it is taught, that is the input mix of educational resources and, of course, evaluation and assessment, that is to what degree as the resource mix accomplished the intended outcomes.

In terms of the schools' curriculum—schools curriculum needs to be expanded to deliberately enhance cognitive skills associated with encoding and decoding of picture data, current educational systems, emphasized cognitive skilled development for encoding and decoding text and verbal data, that is, reading and writing, primarily logical deductive oriented in developing the intellect in our basic educational systems.

Schools need to move from a two-dimensional symbol-based curriculum to a four-dimensional multisensory curriculum, that is, we need to not only develop a verbal literacy but we need to develop visual literacy skills as well if we are going to educate the whole brain.

Dr. Massey spoke about the importance of scientific visualization in this regards. The schools' curriculum needs to compete with Nintendo and Blockbuster.

As far as instruction, school teachers have expressed, in my experience, strong support for student learning experiences with the aid of interactive visual and motion picture educational resources. As such, we have seen the development of interactive video disc-based learning systems, hence, video disc is essentially a medium for storing analog images and motion video.

These enhanced educational materials are being developed in two formats. One is a maturing format, one is an emerging format. Maturing format is that area which is commonly referred to as interactive video disc instruction. In this format, data is principally stored in what is called "analog format," that is, like TV.

Second, the materials are interactive in nature, that is, information flows both ways in the learning activity, from student to computer, and from video disc and computer to the learner.

And, thirdly, experience has shown that these technologies provide learning experiences that are exciting and motivating. The learner maintains greater control of the learning experience. The learner can choose his or her path for learning based on choices provide the learner.

The learner can discover concepts and principles. But this is insufficient because in most of these systems, students do not have the opportunity to do the things that are most natural in their learning process; that is to design, develop, create and produce, and to evaluate the production of their experiences—that this is where the second emerging technology can play a very important role, and that's what I have labeled as the interactive digital multimedia instructional—

Mr. **Swett**. Excuse me, Dr. Tuscher. We are in the midst of a vote on the journal, and with great apologies I would like to ask if you could refrain from the next paragraph until we are able to reconvene after making our votes.

At this point in time, I would like to recess this subcommittee so that the Members can vote, and we will reconvene in five to ten minutes. Thank you.

[Recess.]

Mr. **Valentine**. [presiding] All right, Dr. Tuscher, we'll try to get started again. If you would help us, and we would greatly appreciate it if you could summarize the remainder of your statement—we have other witnesses and we don't want to cut anybody short, but we would appreciate that very much.

Dr. **Tuscher**. Thank you, Mr. Chairman.

In summary, I've discussed two technologies which I believe have demonstrated the potential for improving learning productivity.

One, which we passed over very quickly, had integrated learning systems which are—will be demonstrated here today. They provide a model for outcome-based instruction with a management focus that requires a total change, or I should say a role change—not a total change—for teachers.

It has been said by a fourth grade teacher of experiencing with this system in the State of Washington, teaching fourth grade, says, I've moved from being the sage on the stage to the guide on the sign.

The second technology talked about was the interactive digital multimedia . This considers new design features to enhance learning capability of the whole intellect.

These changes, in essence, will require, (1) capital investment in the smart machines; (2) extensive teacher training in managing outcome-based learning and; (3) smarter software, the development of digitally enhanced technology-based learning environments.

Thank you very much, Mr. Chairman, that concludes my summary.

[The prepared statement of Dr. Tuscher follows:]

Written Testimony before the Subcommittee on Technology and Competitiveness of the House of Representatives Committee on Science, Space, and Technology Hearing on

Interactive Digital Multimedia and School Learning Environments

by

Leroy J. Tuscher
Professor of Education and Computer Science
Lehigh University

June 18, 1991

Interactive Digital Multimedia and School Learning Environments

by

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Professor of Education and Computer Science
Lehigh University

Introduction

During the last two decades new generations of information technology have transformed many of society's institutions by influencing new structures, functions, and roles. Within schools however, information technologies have had limited impact on the administrative infrastructure, school organization, teaching functions and roles, and learning productivity.

Advocates of school reform have articulated a host of challenging problems facing American education and have trumpeted a call for a "restructured" educational system to meet society's changing expectations of school outcomes and student performance (Brannson, 1987; Kearns and Doyle, 1988; Shanker, 1990, Conley, 1991; and others). A recent analysis of the factors related to school restructuring identifies the economic, social-political, and technological forces that are generating an increasingly wide gap between the emerging structures of society and the organization and goals of schools (Conley, 1991). The study identifies two major technological forces that have implications for the integration of technology into the schools' curriculum and instructional processes. They are 1) the changing structure and accessibility of knowledge and 2) the way information is being portrayed.

A variety of communication technologies such as the optical disk (CD-ROM and videodisc), cable TV, and satellite technologies are changing the ways in which the learner can interact with information and knowledge domains beyond the school and classroom. Changes in the way the learner interacts with information will also change as the communication technologies rapidly move toward a world in which most information and entertainment will be prepared and delivered in digital form. Text and sound resources are all nearly digital in form already. Graphic creations and illustrations, still images and three-dimensional graphics have proceeded in the same direction. And digital video will become standard on the microcomputer desktop in the not too distant future. Digital computer imaging opens up the power to communicate information efficiently and effectively in ways unattainable before. Graphic productions, scientific visualizations, integration of real and surrealistic images, digital animations, and entire computer-generated microworlds are the new tools available for designing and developing motivating interactive learning environments. However, school curricula are still being designed with yesterday's technology.

Conley (1991) writing on the changing nature of information representation from two-dimensional symbol based to four-dimensional sensory based and schools states:

> ... The public schools persist in treating visual data as a distraction from the basic learning process, which is entirely symbol based and almost devoid of graphical information except in the form of an occasional supplement to "break the boredom" of the traditional lesson.

He further observes that:

> ... The use of multimedia representations of information is not limited to the arenas of science and engineering. All aspects of the work world are seeing its emergence, from marketing to city planning, architecture to accounting. It is almost a certainty that graduates of today's schools will be interpreting information in technology-based systems that employ sound, motion, color, and interactivity.

While some schools have incrementally increased their expenditures for computer, video, and communication technologies during the past decade, many schools do not have the resources for establishing electronic communication networks capable of distributing data for instructional programming on site with local area networks, or with voice and video between remote locations via fiber optics or satellite technology. Universal access to these capabilities would provide the potential for eliminating the inequity of educational access created by the boundedness of time and distance as impediments to learning. As significant and profound as these electronic technologies are, however, they are only a part of the foundation of a developing digital communications learning network and indicators of the revolution that we can anticipate in the application of educational technologies to the functions of teaching, learning, administration, and the evaluation of educationally enriched learning environments in the coming decades.

The successful integration of digital technology into school practice requires a sense of the educational potential of the emerging digital technologies and a vision of how the schools' curriculum, instructional processes, and learning productivity can be enhanced with the utilization of these technologies (Conley, 1991).

Integrating Digital Interactive Multimedia Technologies into School Practice

Projecting a vision for integrating technology into the school culture requires a sense of where technology is moving in general and which specific educational technologies might follow. In this regard the following themes are consistent with what many in the field of communications technology believe to be the backbone of current and projected futures for educational technology in in schools: 1) a digital communications infrastructure that permits access to and the dispersion of knowledge in multiple media modes (voice, data, graphics, animation, and video); 2) an interactive multimedia learning environment that places greater control of the learning experience on the learner; 3) a teaching and learning environment capable of transcending traditional boundaries for delivering and receiving instruction (fiber optic and digital satellite electronic highways) ; and 4) teaching and learning environments f or interconnectivity and collaborative productivity.

While there exists a scarcity of research that speaks directly to the elementary and secondary schools' use of interactive multimedia technology for teaching and learning, studies have been conducted with a variety of different student populations using a range of the different media available for education (McNeil and Nelson, 1991). This research has provided many insights into the potential and practical effects of these technologies in education. The conclusions about the educational impact of these technologies on elementary and secondary education while most promising must be seen as tentative. Without additional, well-directed research, there is only limited experimental confirmation and statistical support for many instructional claims.

Nevertheless, three desirable educational outcomes seem to be clearly supported by the research evidence available to date. First, achievement on cognitive instruction using multimedia technology is as good or better than that provided by traditional instruction. Second, the use of multimedia for cognitive and skills instruction is an efficient method of teaching. Improvements in efficiency range from twenty to over forty percent, suggesting significant improvements in learning productivity available from multimedia technology. Third, student attitudes towards learning and towards using technology are improved following experience with interactive multimedia learning opportunities.

There are other incidental advantages of interactive multimedia instruction reported in the research literature. These include: the use of the technology provides additional time for individual instruction and follow-up; student production efforts enhance independence, self-concept and motivation; and the interactive nature of the experience appears to enhance retention. The use of advanced multimedia technologies in instruction also provides a platform for enhancing student visual and technological literacy.

Changes in both the philosophical approach to teaching of the content domains and in the technology available to enhance the educational process have always required some evolutionary approaches in basic education. However, the need to restructure educational experiences in these school disciplines has never been greater than it is today. The revolution in personal computing and the digital interchange of all media formats, as yet incompletely absorbed by educational institutions, will be dramatically enhanced by local, national and international digital networking capabilities. Moreover, optical disc technology has matured to the point where vast amounts of textual, graphic, and motion video information in digital format can be interactively accessed from desktop computing. However, most basic educational institutions are neither prepared to effectively utilize these interactive multimedia delivery systems nor are teachers adequately prepared to integrate multimedia into the mainstream of the instructional process. ***Thus, the need for teacher training to effectively integrate interactive multimedia technology in the school curriculum and instructional delivery processes becomes an imperative requirement..***

The new interactive multimedia technologies have the potential to enhance teaching and to influence a fundamental restructuring of curricula and teaching methods as well. With vast amounts of information of all kinds available, the emphasis must shift from data generation and rote learning to understanding how to sort, utilize, integrate, and apply knowledge and become proficient at problem solving. The requirement that students work at high levels of knowledge across all aspects of the curriculum mandates a rethinking of educational philosophy and practice in virtually all knowledge domains. Thus, better ways need to be found to help students build an integrated intellectual structure of scientific principles and seminal observations. Interactive digital multimedia technologies provide one path toward this end. The advent of the computer actually may have fostered an algorithmic cognitive view of the world based on procedures rather than on conceptualization. New cognitive skills need to be developed to enable students to encode and decode visual data. Just as reading is a related but distinct cognitive process from writing, creating and manipulating media is a separate and distinct process from viewing media. Media literacy requires an interactive process with the media. Ironically, this change may well mean an expanded role for computers in science and technology education. That is, rather than merely teaching programming, computers would be used for simulation, in networked hypermedia learning environments, and empowered learning environments. As such, the negative effects of the advent of the computer age ultimately will be seen as transitory growing pains.

The above themes suggest a distributed school , that is, one with a communications infrastructure supporting interactive digital multimedia delivery systems and intellectual productivity work environments with access to learning resources around the globe. This interactive multimedia learning environment would be capable of collaborative interaction with teachers and students; have information technology imaging capabilities for receiving and transmitting print and non-print documents; and have electronic access to institutional services and resources normally available only during the school day extended to access times beyond the regular school day.

Interactive Digital Multimedia Curriculum Development

Designers of curricula in basic education must be attentive to developing high order thinking skills and techniques for the retrieval, analysis, and reporting of information from large multimedia data bases and information domains. Stefik (1986) speculates that the next generation of information technologies (advanced graphics workstations, optical disc technology, cognitive science, information networking, and expert systems) could become history's first "knowledge medium: humanity's conscious mechanism for tailoring its cognitive evolution." This prospect has emerged, in part, because computer capabilities for receiving, processing, and transmitting information have steadily increased while the costs have concomitantly decreased over the last four decades.

Of what value is this increased power of advanced technologies in the educational environment unless it can be harnessed for more productive learning? New types of applications are being designed, developed, and tested which take advantage of the advanced functions provided by the new interactive multimedia digital technologies. These new instructional applications are referred to in the research literature as interactive multimedia instruction, intelligent tutoring systems, and cognition enhancers (Brown 1982, 1985; Dede, 1986).

Intelligent tutoring systems are more complex than expert systems in that they not only require an expert system base but they must have a learner diagnostic mode and a prescriptive mode to direct the activities of the learner. Intelligent tutoring systems are complex and specialized requiring heavy development costs. Of the some 15 intelligent tutoring systems identified as having reached the full stage of development, only 5 are used on some regular basis and only recently have any been systematically evaluated as to their effectiveness (Romiszowski, 1987; Burns,et al, 1991). The educational value of these systems need to be determined by designing, developing, and evaluating intelligent tutoring systems in real school environments. In this regards a Cooperative Research and Development agreement was signed this last April between the Human Resources

Directorate of Armstrong Laboratory at Brooks Air Force Base, Sage Educational Systems, Lehigh University, and the University of Texas at San Antonio. The agreement was orchestrated to facilitate the extended study and transfer of intelligent tutoring systems (ITS) to our nation's schools under the banner of the Fundamental Skills Project. The project will develop, test, and evaluate interactive digital video based intelligent tutoring systems for basic mathematics, reading/writing, and basic science during the next three years. ***This scenario of the collaborative development, testing, and the transfer of promising technologies for teaching and learning into the schools of America needs to be replayed again and again.***

Cognition enhancing learning environments are conceptually designed to take advantage of the complimentary cognitive strengths of the learner and an information technology. The tradeoff in cognitive strengths considers the relative advantage of each in terms of storage capacity, short-term memory, long-term memory, speed of computation, linear and semantic networks, and standardized problem solving versus ill-structured problem solving. While intelligent tutors will gradually become useful in educational environments, cognition enhancers designed to take advantage of the combined strengths of humans and computers will evolve much faster. These tools are still in their infancy. Nevertheless, three kinds of cognition enhancers seem to be emerging: empowering environments, hypermedia, and microworlds (Dede, 1987).

In empowering environments, the machine handles the routine tasks of the learning requirements while the person concentrates on higher order cognitive tasks. An example of this kind of environment is the Writers Bookshelf, a computer memory resident cognition enhancer which provides on-line access to 10 data bases and reference documents to a writer utilizing a word-processing program. The system, once accessed, includes support useful for real-time composition of a document; notable among these empowering devices are thesauri, dictionaries, and a grammar checker.

Hypermedia are cognition enhancers which provide a non-linear representation of text, audio, images and video in a semantic network linking multimedia information sources to enrich the learning experience (Dwyer, 1987). Research data suggests that a variety of learning stimuli, multimedia instructional resources, may enhance both the short-term and the long-term recall of learned materials (Clark, 1984). Studies by Dalton and Hannafin (1986) show that the combination of interactive video and CAI maintains a high degree of active learner participation in the learning process. An example of hypermediated learning would be the development and use of an interactive multimedia illustrated textbook that interrelates textual information, audio, visual images and motion video all in a digital format. This could be accomplished by using hypertext application development software such as Linkway™ offered by IBM or HyperCard™ offered by Apple Computer, Inc., along with interactive optical disc technologies to create mediated learning environments or preferably in a completely digital environment using Intel's Digital Video Interactive (DVI™) technology or similar emerging digital technologies. As part of a beta-site test program with Intel, Lehigh University had the opportunity to work with an early version of the DVI™ technology. The goal of the test site application development was to create a motivating, interactive educational application which utilized the digital multimedia capabilities provided by DVI™. An application was developed, Digital Dinosaurs, that allowed elementary school children to discover, explore, design, and create dinosaurs and dinosaur habitats in a media enriched activity-based learning environment. The application consists of five primary activities: Arrange-A-Saur, Dino-Paint, Make-A-Habitat, Arrange-A-You, and Construct-A-Saur. Arrange-A-Saur is a puzzle game in which the puzzle pieces consist of blocks from a digitized dinosaur image which are scrambled on the screen. The successful completion of the puzzle introduces the learner to the life and times of the dinosaur with digital video and other media formats. Dino-Paint is a creative activity which uses several resizable dinosaur images as a painting tool. Make-A-Habitat is a painting activity which lets the user create different habitats for the dinosaurs. Arrange-A-You is an adaptation of the Arrange-A-Saur puzzle game in which the user's picture is captured from an attached video camera and is dynamically digitized and imported into the application to be used as the puzzle pieces or for the composition of a personal story about dinosaurs. Construct-A-Saur is an archaeological activity in which the user recreates a dinosaur skeleton from the provided bone segments. At any time throughout the Digital Dinosaurs application, additional information on dinosaurs is available in a variety of media formats. The narrator is an animated dinosaur called Expert-A-Saur who provides facts and data on dinosaurs to enhance the learning activity. The learning activities for Digital Dinosaurs were designed to provide the student with learning activities to explore, create, and evaluate their own learning experience in a motivating game-like environment.

Microworlds are content rich expert-based domains that link abstract comprehension to real world applications. Microworlds, first described by Seymour Papert, developer and chief proponent of the Logo philosophy of learner-centered and learner-controlled applications of technology to education serve as "incubators of knowledge . . . in which certain kinds of thinking can hatch and grow with particular ease" (Papert, 1980). Hurley (1985), for example, has described a series of computer microworlds for developing understanding of planetary motion, radioactive decay, conservation of momentum, and other concepts of physics. Another example of this type of cognition enhancer might be the development of a flight simulation microworld that physically and graphically depicts the lift-off and landing of a space shuttle and space exploration in which the learner can control the conditions impacting the flight of a space shuttle.

The potential for improving learning productivity with cognition enhancers, hypermedia, and empowering tools seems high, yet few learning environments take advantage of this potential. Perhaps because very little information exists on how best to design and develop learning environments using advanced interactive multimedia technologies. Research is needed to establish design criteria and procedures for developing effective intelligent tools for enhancing teaching and learning in information intensive environments. New technologies offer the promise of new ways of providing evaluative feedback to the learner in the form of multiple media stimuli. It also provides the learner with a wider range of ways to respond to curriculum based evaluative questioning. New technologies can promote the development of new tests to focus on higher order cognitive skills in ways not currently utilized (Madaus, 1987). ***Therefore, new technology based testing procedures and techniques need to be developed to promote higher order cognitive skills. The need exists to develop, implement and evaluate cognition enhancers in the critical fields of science and technology education. An aggressive long-term research agenda needs to be generated for studying the impact of innovative new information technologies in specific curricula in elementary and secondary educational institutions.***

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Mr. Valentine. Thank you, sir.

I will recognize Dr. Houlihan at this time unless Mr. Joseph, you don't have any problem. I see that you're local and he's got an airplane to catch.

Dr. Houlihan.

Dr. Houlihan. Thank you very much, Mr. Chairman. It's a pleasure to be with you today.

I've heard a great deal—I've learned a lot today, and perhaps it is appropriate at this point that a practitioner share with the—the hearing some—some ideas.

I'd like to begin by talking about the-the obvious disparity that exists between the use of technology in our schools and what's available. And I'd like to do that by sharing with you two quotes that I think are most appropriate.

The first quote is by Frank Shrontz, who's Chairman and CEO of the Boeing Company, and he says, "America's future will; be no greater than the one we prepare our children to build. We must not handicap them with obsolete tools."

Compare that by sharing with you another quote from the famous person Anonymous that says, "In the United States, schools and churches are the only remaining institutions that still rely on the old-fashioned ditto machine as a major source of technology."

And I think it shows in those two quotes the disparity that exists, and I'd like to share with you why I believe that's the case.

First, education is vastly underfunded and/or vastly over-regulated. We do spend a lot of money on schools but the regulations and the categorization of that money often handicaps the use of that money appropriately.

Second, as has been said many times, and I won't go into this, schools today operate the same as we did 30 or 40 years ago. And an interesting article that appeared in Time, September the 14th of 1959, gives a dire warning of what would happen if our schools did not change. The warnings that were raised in that article have in fact come true in 1991.

And the third reason I think this disparity exists is because technology is misunderstood and feared by many educators—a fear of losing control, a fear that computers will replace teachers, and the fear that some students very well may know more than the adults do in the schools.

And I think that fear is a genuine one when we consider the fact that there is a clear lack of clarity regarding consensus as to what our schools are all about. And when there is a lack of consensus about what schools should and should not be doing, fear is often the result.

In spite of these issues, education must incorporate technology in the everyday practices of our schools, once again, for three reasons:

First, children today are visual learners. I believe that many of the discipline and dropout problems we have are related to student frustration and boredom with the schools that exist.

Also, kids are increasingly sophisticated and knowledgeable. The traditional lecture test, lecture method, of classroom instruction is not appropriate in today's world.

A second reason why we must incorporate technology is that technology can provide a catalyst to move schools as organizations forward towards the 21st century. We often forget that the vast array of knowledge that is out there and it's growing, and it's growing so fast that unless we incorporate technology into our schools, I believe we're going to fall further and further behind.

And, finally, and most importantly, as Alvin Toffler states, "teachers who do not understand the future will do incredible damage to their students."

We can talk about the global issues of technology today, and they're very important; we can talk about the competitiveness of our country, and that's very important; but as a superintendent of schools, my job is to make sure the students I work with every day have opportunities to be successful in the future. That is why I think technology is most important—to give those young people that we work with every day an opportunity to be successful no matter what they choose to do in the future.

Thank you very much.

[The prepared statement of Dr. Houlihan follows:]

EDUCATIONAL TECHNOLOGY: COMPUTER-BASED INSTRUCTION

Dr. G. Thomas Houlihan, Panel Member
Superintendent, Johnston County Schools
Smithfield, North Carolina
Committee on Science, Space and Technology
U. S. House of Representatives

"America's future will be no greater than the one we prepare our children to build. We must not handicap them with obsolete tools."
-Frank Shrontz, Chairman & CEO
The Boeing Company

"In the United States, schools and churches are the only remaining institutions that still rely on the old fashioned ditto machine as a major source of technology."
-Anonymous

OVERVIEW:

As a practicing educator for the past nineteen years, I have observed the growing disparity between the availability of sophisticated technology for learning and the use of this technology in public education. There are many reasons for the disparity, but the simple fact remains; K-12 education in America is woefully behind when it comes to the use of computer-based instruction in our schools.

There are three primary reasons why this disparity exists. First, the cost of technology is often prohibitive. Education in America is vastly under-funded, with such basic issues as school facilities, materials/supplies, and even telephones being in short supply. Tax dollars to fund expensive technology above the basic infrastructure needs in public education are not a priority in most school system budgets.

Second, the American system of education is locked in a post-world war II mode of operation. Teacher preparation, delivery of instruction, and evaluation systems have not changed in many public education systems. Because our schools are organized similar to schools 40 years ago, technology is not viewed as important, or is not understood, by the vast majority of educators in our schools.

The twin issues of funding and organizational structure have contributed to a lack of usage of technological advancements in the schools of America.

A third reason for the lack of technology usage in public education is the historical haphazard, fragmented options previously available to consumers. Educators are skeptical of the value of computer based instruction, because the software available has been of questionable value. A great deal of the software designed for computer based instruction has been designed primarily to be compatible with the type of hardware being used, with little attention to correlation of curriculum or theory-based instructional techniques. In short, educators have become increasingly suspicious of computer based instruction because of the fragmented software being sold.

In spite of the reasons why computer-based technology is not being used in many school systems, there is great optimism for the future. Having worked in a school system where technology was used to dramatically improve student achievement, I am convinced that technology holds the key to the future of education in this country. Until and unless we take dramatic steps forward in the area of technology in our schools, I am convinced American education will not be able to compete on a global scale. This country really has no options; we must use the increasingly sophisticated forms of technology if our children are going to succeed.

America's children learn in many ways vastly different from the way you and I processed information. Today's young people are visual learners because this generation has grown up with television, video-discs and cam-corders. While it may be very difficult for you and I to play Nintendo successfully, our nine and ten-year olds are quite adept with this game. The point is very simple; children often know far more about technology than adults do; consequently, we must find ways to teach children that correspond to their natural predisposition to learn. The days of lecturing for an entire period must come to an end, to be replaced with computer screens that provide visual stimulation and excitement for the learner.

One of the most telling success stories I have observed first-hand is the achievement gains that can occur among students labeled as "at risk" or from lower socio-economic living conditions. In one school, for example, students achieved a gain of 57% in reading after a computer-based learning system was installed in that school. This particular school contained students that traditional wisdom says are "at-risk". Over 60% of the students were minority, many coming from housing projects in the attendance area. The per capita income of this school's population was approximately $11,000; many of the parents of these children were on welfare. Three years after the computer learning system was installed, that school was selected as a U. S. Department of Educational "National School of Excellence". I am convinced this dramatic change would not have occurred without the use of technology in the school setting.

Perhaps a specific example would be of assistance. As I walked past the previously mentioned school's computer lab one day, I noticed a young man busily working on the computer. What caught my attention was the fact that he was standing at the terminal, deeply engrossed in the task at hand. The chair that was provided for him to sit on had been pushed aside. Knowing that this particular young man came from a "disadvantaged" home situation, was constantly in disciplinary trouble at school, I stopped and watched him at work. As problem after problem was answered correctly by this young man, I became very impressed with his ability to complete his assignments so well.

As he completed the assignment on the computer, I asked him why he was doing so well. His answer was starkly revealing; "It's fun to learn this way, but most of all the computer don't talk back and tell me I'm dumb". From that day forward, I have become convinced that the use of computer-based instruction holds the key to future success for many of our young people.

FUTURE CONSIDERATIONS

As important as this hearing is to the future of computer-based instruction in America's schools, I would urge the Committee to expand its emphasis and refine the questions being asked. The missing element underlying the questions being raised by this Committee is any sense of schools as systematic work processes, the nature of quality work processes (in any setting) and the relationships of information technology to empowerment of those work processes.

There are a number of key questions that need to be asked first to ensure that the questions currently being asked are focused on the real issues. For example:

- Why would school practitioners (all seemingly intelligent, college educated adults sharing concerns about children) be the only professionals in our society that appear to "resist" technology?
- Why is education the only work setting where tools are provided for the clients, before the workers?
- Why are schools the only professional work settings where the professionals have no way to interact with each other about problems as part of their daily process of solving them?
- Should teachers have telephones?

The bottom line answers to these questions frame the depth of the delivery paradigm in America today. The schools of the 40's and 50's delivered instruction via lecture, rote memorization and regurgitation of the material delivered. If this same delivery system is the prevailing view in the 1990's, the use of computer-based instruction is not likely to be successful.

I contend the schools of the 1990's must look at the issue of management of information-driven systems and the process of continuously adapting resources to accomplish purposes. We have not provided teachers and principals with the basic information to do this job.

John Gardner once termed our culture's understanding of social service delivery as a "Penny Gumball Machine" mentality. People see resources going in at the top and outcomes (in our case, learning) emerging at the bottom. This mental set may be the real barrier to the effective use of technology in our schools of the 1990's.

Today's leaders call for quality learning outcomes and more productive schools and school practitioners. But, because many of these leaders cannot yet apply what they are learning in the private sector about the connection between personal productivity and quality outcomes to the total work processes of schools, our system of education continues to flounder.

The issue of computer-based instruction is critical to the future of American education. As policy-makers, I urge you to help improve the quality of learning by shifting from a mindset of blaming teachers and principals for our woes to a mindset of fixing the process we use to educate students. Quality is highly dependent upon productivity, and productivity in our schools, as in the private sector, requires technology.

This nation's schools can and must incorporate technology into the system of education. But, the process we use to educate children must change, and this nation's mindset about delivery of instruction must change, if we are to systematically improve education in America.

BIOGRAPHICAL SKETCH OF G. THOMAS HOULIHAN

Dr. Houlihan received his B. S. Degree from Indiana University, a Master's from North Carolina State University and a Doctorate in Educational Administration from the University of North Carolina at Chapel Hill. He has been teacher, guidance counselor, principal, associate superintendent and superintendent in the schools of North Carolina. In addition, he served as President/CEO of Community Leaders Allied for Superior Schools in Indianapolis, Indiana (an organization of CEOs designed to improve education in the Indianapolis area).

In 1990, Dr. Houlihan was North Carolina's Superintendent of the Year and a finalist for National Superintendent of the Year. He was the 1990 Indiana University School of Education Alumnus of the Year. In 1988, Dr. Houlihan authored School Effectiveness; The Key Ingredients of Schools With Heart.

Mr. **Valentine**. Thank you, Dr. Houlihan.

Mr. Joseph?

Mr. **Joseph**. Thank you, Mr. Chairman. I appreciate the opportunity to be here and I appreciate the comments of everyone who preceded me.

Business community has great concerns about the future well-being of this country as—as evidenced by the people in the work force today and the amount of training they will need to take us forward as well as the—the poor numbers who are coming forward from the school systems.

And so it's not surprising when—when Secretary Kearns talks about the involvement of the broad-based business groups in trying to support and coordinate what the President and the governors are trying to do; because today America faces a challenge that will require tremendous resilience to meet.

Sophisticated technology is rapidly changing virtually every aspect of the way Americans work and live. As we all know, the value of unskilled labor is rapidly disappearing. In the workplace of today, employees on the factory floor must be highly literate and computer friendly. Skilled requirements are changing dramatically and increasingly require independent judgment as well as analytical and interpersonal skills.

For example, manufacturing and machinist occupations are evolving quickly from jobs involving simple repetitive motions to those of technicians or technologists.

In the service industry, for example, secretaries are now information managers. Bank tellers or financial services—portfolio consultants. Even delivery services like Federal Express now use computerized tracking systems that employees are expected to operate and to understand.

And the comment has already been made about the huge number of people in the work force between 70 and 80 percent of the people in the work force today who will need constant retraining to take us into the year 2000 and beyond.

So if America is to maintain its economic vigor and preserve its standard of living into the 21st century, it must embark on a draconian campaign to reinvigorate our school systems and to meet the training needs of our current work force.

Now, we believe incorporating much of the past decades technological advancements into the classrooms and work environments is a viable solution. Because, after all, it's the modern technology that we now recognize as compelling the need to change our schools as well as improve the caliber of our work force.

Now, many U.S. corporations already utilize technological training devices to upgrade the skills of their employees. The worker education departments of private businesses spend an average of 30 percent of their budgets on computer-based instruction. That's a share of about 300 times larger than public schools.

Let me also add at this point that most of the data we have comes from the big companies—Fortune 500 to be concerned. But if you look at who they are, the high-tech companies, the higher tech they are, the greater percentage of their budget they spend on training because they know how—how much people need to stay ahead of the curve.

It's also important to note that very little data exists about the training needs and programs of small to medium-size employers. And we believe that that's something this committee can help do, is get the right government agencies focusing on that.

My formal statement also incorporates a number of specifics of companies and local chambers of commerce, what they're doing around the country to spur this kind of—of application of technology to schools. And also appended to my statement is a recent article from a special supplement from Fortune magazine about what companies are doing to bring technology to classrooms that we feel should be read by many.

Local business people, through local chambers of commerce, are trying to help. They recognize that schools can only be reformed from the bottom up, through 16,000 local school districts, meeting well into the evening, and figuring out how they are going to implement the necessary changes that as a Nation we set out in a framework.

And we believe that while the local business people can't come to the table and try and tell teachers how to teach—because that's not their job—they can make the case that technology has changed the way they've operated their businesses over the last 10 years. And while they were afraid of computers, too, that we have to get on with it and put technology into the schools so that people can be trained, come out knowing how to—how to do what needs to be done.

Quite frankly, we're very concerned, because even though the President's program and that the governors' support is very admirable, and would establish 535 model schools—that's about five years from now. And there are 100,000 schools out there today that are all struggling and floundering, and the business community needs them all to be revitalized as soon as possible.

And technology is something we can do today into all of these schools. Because it's important to note that classroom technology is falling behind that of the real world at an accelerating pace.

While the rest of America created a $20 billion industry by putting some 45 million personal computers into use over the last 10 years, U.S. schools acquired a mere $2 billion worth of PCs. Not surprisingly, there are 10 times as many Nintendos in homes as computers in schools. And today we invest only about $100 per student in education for computers and capital equipment compared with $50,000 per worker in private industry, and more than 100,000 for a worker in a high-tech firm.

So let me quickly summarize some of the recommendations that we ask you to look into.

First, as I recall making the statement, there is not enough data about the small and medium-size companies on what they're doing in the training area. And since half the people who will come out of school and go to work, will go to work for these smaller businesses, there needs to be some linkage back as to what specific training skills need to be focused on in the educational process. Perhaps the Department of Labor or Small Business Administration can do a better job of tracking that.

We also think that we have to get on with the injection in a massive way of technology into schools, as I mentioned through that

Fortune supplement. But also, I think the Congress has to go back and consider maybe federal tax incentives. I know supposedly the tax code isn't going to be touched any time soon, but you never know. And if we really want to encourage this corporate involvement and corporate generosity, you can have quicker write off of—of computers used in school.

Computer technology is moving so fast that the technological prowess doubles every year and the cost gets cut in half. So before you know it, there are plenty of businesses that will have a year and two-year-old computers that they have to junk—they could junk if the tax code allowed them to write them off a little faster, and perhaps they could put those into schools.

Let me also mention something else that gets overlooked, I think, by many in the Congress when you focus on education policy. Uncle Sam, in his own way, is the largest trainer of adults and educator of children through the military, in terms of base schools and in terms of all the people who are trained to go into the military, and all the constant retraining through the Reserves.

And there are large amounts of dollars being allocated in—in that pot, and perhaps there's a way to bridge the gap and find ways to share some of the programs or share some of the technology; or perhaps even consider, as we downsize the military and close bases, taking computer equipment that exists and trying to move it into the community so other people can share.

And, finally, we think that people need to support the effort of the President's and the governor—the President and the governors—to move America 2000 along.

And close with the last point other people have made, that we understand that teacher training is key to this, that there needs to be the same national imperative to bring the teachers up to speed so they feel comfortable, and we need to make sure that—that the community at large and the Nation at large is committed to bringing technology on line as soon as possible.

Thank you.

[The prepared statement of Mr. Joseph follows:]

Statement of the U.S. Chamber of Commerce

ON: EDUCATIONAL TECHNOLOGY: COMPUTER-BASED INSTRUCTION

TO: SUBCOMMITTEE ON TECHNOLOGY AND COMPETITIVENESS OF THE HOUSE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

BY: JEFFREY H. JOSEPH

DATE: JUNE 18, 1991

The Chamber's mission is to advance human progress through an economic,
political and social system based on individual freedom,
incentive, initiative, opportunity and responsibility.

The U.S. Chamber of Commerce is the world's largest federation of business companies and associations and is the principal spokesman for the American business community. It represents nearly 180,000 businesses and organizations, such as local/state chambers of commerce and trade/professional associations.

More than 93 percent of the Chamber's members are small business firms with fewer than 100 employees, 60 percent with fewer than 10 employees. Yet, virtually all of the nation's largest companies are also active members. We are particularly cognizant of the problems of smaller businesses, as well as issues facing the business community at large.

Besides representing a cross section of the American business community in terms of number of employees, the Chamber represents a wide management spectrum by type of business and location. Each major classification of American business -- manufacturing, retailing, services, construction, wholesaling, and finance -- numbers more than 10,000 members. Yet no one group constitutes as much as 32 percent of the total membership. Further, the Chamber has substantial membership in all 50 states.

The Chamber's international reach is substantial as well. It believes that global interdependence provides an opportunity, not a threat. In addition to the 61 American Chambers of Commerce Abroad, an increasing number of members are engaged in the export and import of both goods and services and have ongoing investment activities. The Chamber favors strengthened international competitiveness and opposes artificial U.S. and foreign barriers to international business.

Positions on national issues are developed by a cross section of its members serving on committees, subcommittees and task forces. Currently, some 1,800 business people participate in this process.

STATEMENT
on
EDUCATIONAL TECHNOLOGY: COMPUTER-BASED INSTRUCTION
before the
SUBCOMMITTEE ON TECHNOLOGY AND COMPETITIVENESS
of the
HOUSE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
for the
U.S. CHAMBER OF COMMERCE
by
Jeffrey H. Joseph
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INTRODUCTION

The U.S. Chamber of Commerce commends the Subcommittee on Technology and Competitiveness for recognizing the importance of educational technology and its relation to our nation's economic vitality and competitive strength. The Chamber also appreciates the opportunity to present the business community's views on this critical issue.

I am Jeff Joseph, Vice President for Domestic Policy at the U.S. Chamber of Commerce. I also serve as Executive Vice President to the Chamber's affiliate, the Center for Workforce Preparation and Quality Education. Accompanying me is Jill L. Scheldrup, State and Local Program Manager of the Center.

The Chamber is deeply committed to improving education and workforce quality, and places high priority on incorporating educational technology into classrooms across the nation. This testimony will present the Chamber's views on educational technology's potential impact on today's job market and will outline why computer-based learning is beneficial for private industry and American schools.

This country has experienced a dramatic rate of technological acceleration over the past decade -- one that shows no signs of slowing. To that end, this testimony will also recommend that the following actions be taken by this Subcommittee:

1. Focus national attention on the need to equip school students with technological skills and to upgrade the skills of our current workforce;

2. Direct the Small Business Administration or U.S. Department of Labor to collect data on the training practices and skill demands of small- to medium-sized companies;

3. Work with the Bush Administration, state governments, and business and education leaders to establish model technology schools for all ages and abilities;

4. Provide teachers with appropriate training and assistance in the application of educational technology; and

5. Ensure that educational technology and the use of computer-based instruction become part of AMERICA 2000, President Bush's education strategy.

EDUCATIONAL TECHNOLOGY AND THE AMERICAN JOB MARKET

Today, America faces a challenge that will require tremendous resilience to meet. Sophisticated technology is rapidly changing virtually every aspect of the way Americans work and live. There was a time when any average high school graduate with basic mechanical aptitude could expect to find meaningful employment in industry. That day is gone. The value of unskilled labor is rapidly disappearing. In the workplace of today, employees on the factory floor must be highly literate and computer-friendly. Skill requirements are changing dramatically, and increasingly require independent judgement as well as analytical and interpersonal skills.

For example, manufacturing and machinist occupations are evolving quickly from jobs involving simple repetitive motions to those of technicians or technologists. In the service industry, secretaries are becoming information managers; and bank tellers are becoming financial services portfolio consultants. Even delivery services like Federal Express now use a computerized tracking system that employees are expected to operate and understand. These types of developments will continue well into the 21st century.

According to the U.S. Department of Labor's Bureau of Labor Statistics, more than 50 percent of jobs created between 1985 and 2000 will require some education beyond high school. Blue collar or manual labor positions will continue to decline -- from roughly 40 percent of all jobs in 1970 to 27 percent in 2000. In the interim, demand for white collar work will escalate. Executive, administrative, and professional specialty occupations will comprise 30 percent of all employment positions. These jobs require the highest proportion of workers with at least four years of college. Today, only 22 percent of all occupations require a college degree.

With well over 70 percent of employees in the year 2000 already in the workforce, training needs will be immense. The American Society for Training and Development (ASTD) reports that 49.5 million workers, or 42 percent of the workforce, will need additional training within the next ten years to keep pace with employer skill demands. Sixteen million will need skills and technical training; 5.5 million will require executive, managerial, or supervisory training; 11 million will need customer service training; and a whopping 17 million will require training in basic skills. These figures do not include the approximately 37 million workers who will need entry-level training. Attached to these training needs is an enormous price tag for employers, who already spend more than $30 billion in training, retraining, and remedial education each year.

Current trends in education performance exacerbate the difficulty business will face in finding skilled workers to fill the complex and knowledge-intensive jobs of the future. Statistics on these trends are all-too-familiar. The U.S. national dropout rate is 26 percent, rising to 50 percent in some inner cities. Of those who graduate, about 700,000 cannot read their diplomas. Only half of our 17-year-olds compute well enough to use decimals and fractions, recognize geometric figures, and solve simple equations.

Clearly, if America is to maintain its economic vigor and preserve its standard of living into the 21st century, it must embark upon a draconian campaign to re-invigorate our school systems and meet the training needs of our current workforce. Incorporating much of the past decade's technological advancements into classroom and work environments is a viable solution. After all, it is because of modern technology that we now recognize the compelling need to change our schools, as well as improve the caliber of our workforce.

Many U.S. corporations already utilize technological training devices to upgrade the skills of their employees. The worker-education departments of private businesses spend an average of 30 percent of their budgets on computer-based instruction -- a share about 300 times more than public schools. Employee educators in leading companies are replacing three-quarters or more of their classroom teaching with instruction delivered by computer and telecommunications systems.

Recent research by ASTD shows that many large companies spend at least twice as much on training as the U.S. average of 1.4 percent of payroll. IBM's total training expenditure is $250 million, or five percent of payroll. Xerox spends $257 million, or four percent of payroll. Texas Instruments invests $45 million, or 3.5 percent of payroll. Much of the positive training effort these companies have demonstrated must be transferred to America's public schools.

It is important to note, however, that little information is available on the training practices of small- to medium-sized employers.

COMPUTER-BASED INSTRUCTION: A CATALYST FOR SCHOOL RESTRUCTURING

Educational technology is gaining national recognition as an effective tool for making schools more efficient, helping teachers to individualize instruction, and affecting positively how and what children learn. Computer-based instruction, a major form of educational technology, can virtually transform the way children are taught. Computers make learning fun for children raised on *Sesame Street*, Nintendo, and MTV. Fortune (Spring, 1990) reports that computer-based instruction captivates students and promotes the skills business values highly -- problem-solving, teamwork, and familiarity with technology. Computers can also help teach learning-disabled children by allowing them to progress at their own pace, providing immediate feedback without passing judgement.

Research on the effects of educational technology and computer-based instruction has produced promising results. In 1990, Bank Street College of Education surveyed 608 teachers who use technology. A majority reported that they were able to tailor lessons to individual students and that students took more initiative and responsibility for their education. Of the 1,100 teachers surveyed by the Wirthlin Group in 1989, 64 percent agreed that computers help stimulate the interest of students most at risk of dropping out.

School districts using technology also report its positive effects on at-risk youth. Orangeburg, South Carolina reduced its dropout rate from 34 percent to eight percent in four years. Volusia County, Florida used a computer-based adult literacy program to raise the reading ability of 300 high school students from a 6th to almost a 9th grade level. Business is getting involved in research as well. Apple has begun spending several million dollars per year on "Apple Classrooms of Tomorrow," a long-term research project that explores how technology affects teaching and learning.

Business and government leaders are joining forces to implement computer-based learning systems into the schools. Since 1979, Apple has donated more than $60 million in computers and equipment. IBM has provided $50 million in computers and training over the same period, and will spend another $50 million in the next five years. Mattel is donating computers to learning-disabled students in Los Angeles, with hopes of expanding this effort into a nationwide program. In 1989, Pacific Bell, IBM, Lockheed, and other corporations successfully lobbied the California legislature for $14 million to support technology in the schools.

Jostens Learning Corporation, a subsidiary of Jostens, Inc., is another leader in the educational technology field. Jostens Learning Corporation develops and markets educational software for pre-school, elementary, secondary, and adult learners. By promoting partnerships between education, business, and/or government leaders, the corporation has helped thousands of financially needy school districts purchase and obtain various forms of technology-based learning programs.

State and local chambers of commerce are taking action as well. The Florida Chamber of Commerce has spearheaded an effort to make instructional technology a fundamental component of education restructuring throughout the state. The Chamber was successful in 1990 and 1991 in getting computer-based instruction incorporated into elementary and secondary classrooms through several million dollars in contributions from business and appropriations from the Florida legislature. Utah is in its second year of an initiative that has placed computers and other forms of instructional technology in each of the state's 40 school districts and four colleges of education. The Utah legislature has appropriated $28 million in the last two years toward this effort, with plans to continue funding through 1994. To date, business has contributed $15 million. The Utah technology initiative is modeled after a business-education partnership program spearheaded by the Provo-Orem Chamber of Commerce. South Carolina is preparing a statewide plan for technology and has formed a task force of business and education leaders. Representatives from the state chamber serve on this committee, and several chamber members are primary resources for task force members. The Texas and Pennsylvania chambers are among other state chambers becoming leaders in the educational technology field.

Representing over 180,000 corporations and 2,900 state and local chambers of commerce, the U.S. Chamber of Commerce is also deeply committed to this effort. The Chamber has created a separate 501(c)3 organization, known as the Center for Workforce Preparation and Quality Education. The Center was created to mobilize a national grassroots campaign to involve business leaders and chamber executives in the education reform movement. Helping local communities meet the new education goals and assisting them in implementing reform proposals called for in AMERICA 2000 are central to the Center's mission. Making educational technology and, more specifically, computer-based instruction, a key part of this decade's education reform agenda will be a Center priority.

EXISTING BARRIERS TO IMPLEMENTATION

While much has been done to incorporate educational technology into classrooms across America, statistics make it painfully clear that our nation is still in the infancy stages of this effort. The implementation of computer-based learning devices in schools has been slow. Much of this is due to resistance to change by the education community, or by complaints of poor-quality computer hardware and software. Another significant barrier facing a computer revolution in the schools is cost. The U.S. Congressional Office of Technology Assessment (OTA) estimates that the U.S. would have to spend $4 billion annually for several years to reduce the student-computer ratio to 3:1.

A substantial majority of schools still lack adequate numbers of computers for instructional use. Glaring deficiencies exist in poor districts and in educating black students or those with limited English proficiency. Estimates in 1990 were that schools averaged one computer for every 20 to 30 students in the schools. In a 1990 survey of

80,000 schools, 97 percent had at least one computer. In 17 percent, the student-computer ratio was 90:1.

Classroom technology is falling behind that of the real world at an accelerating pace. While the rest of America created a $20 billion-a-year industry by putting some 45 million personal computers into use during the last ten years, U.S. schools acquired a mere $2 billion worth of PCs. Not surprisingly, there are ten times as many Nintendos in homes than computers in schools. Today, we invest only about $100 per student in education for computers and capital equipment, compared with $50,000 per worker in private industry, and $100,000 per worker in high-tech firms.

While it is clear that there are companies today in which training is a high-leverage investment, some studies suggest that total U.S. commitment to corporate training is insufficient. According to ASTD's Train America's Workforce, "Only 55 percent of American employees say they received either schooling or formal job training to qualify for their jobs and only 35 percent received formal retraining once at work." Available training is also skewed more toward college graduates. About one in five college graduates are trained by an employer, while only one in 13 employees without college receives training. Additionally, numerous studies indicate that Europeans and Asians commit greater resources than we do to corporate training. ASTD reports that in France, employers are required by law to commit at least one percent of payroll to training. Countries such as Ireland, Germany, Sweden, Denmark, Korea, Singapore, and Japan use a mix of tax incentives and infrastructure jointly governed by industry, labor, and government to sponsor work-based learning.

RECOMMENDATIONS FOR CONGRESSIONAL ACTION

Although education is a state and local function, there are actions that can be taken at the federal level to help facilitate the implementation of educational technology in schools throughout the United States. The federal government may not have adequate resources to make the financial investment needed to transform American school systems, but it can provide direction and play a leadership role -- all in an effort to make educational technology a part of this decade's education reform agenda. What follows are potential courses of action at the federal/national level.

Focus Attention on Small- to Medium-Sized Companies

Small businesses, which employ roughly one-half of the nation's private sector labor force, have been directly affected by technological advances. Often touted as the "economic engine" of this county, America's 18 million small firms experience the same difficulty recruiting skilled labor as do large corporations. During difficult economic times, small companies often are forced to become smaller or forgo expansion.

Because of the vital contribution small business makes to the economic well-being of this country, we must revitalize federal efforts to assist them. To that end, Congress should direct the Small Business Administration or U.S. Department of Labor to examine the extent to which small businesses utilize technology in their training practices. This effort should also include a comprehensive attempt to identify the precise training and skill demands of small employers.

Create High-Technology Pilot Schools

A number of school districts have begun to experiment with super high schools -- schools using the newest technology. These efforts hold much merit. Imagine if all of the latest technology -- personal computers, fiber optics, high-density TV, satellite communications, VCRs, CD-ROMs, high-speed copiers, facsimile transmission, hand-held video cameras, compact audio recorders and players, and nearly limitless software development -- were put together and dedicated to teaching children. Congress, working closely with the Bush Administration, state governments, business leaders, and other private organizations, could help make this a reality by promoting model technology schools for all ages and abilities.

There are a number of avenues through which such an endeavor could be pursued:

1. A number of efforts are already underway to bring low-cost computer networks to the fingertips of teachers and the desk tops of children. A widescale promotional effort should be undertaken at the federal level to encourage states to adopt these systems on a pilot and, ultimately, a state-wide basis. Examples of these efforts are highlighted in a Spring, 1990 special issue of Fortune, which is attached for the Subcommittee members' review.
2. Various federal tax incentives for business to increase its investments in educational technology should be explored. Such incentives would provide a good vehicle for business involvement, as is already done in some European and Asian countries.

3. Federal investments in technology for personnel training, particularly in such areas as Department of Defense National Guard and Reserves, should be made available to communities for public education. This federal seed money is essential to establish high-technology schools.
4. A new round of Presidential leadership could energize support for the expansion of high-technology schools -- possibly through AMERICA 2000.

Revitalize Teacher Training

It is absolutely necessary to provide teachers with training and assistance in the application of educational technologies. Roughly two thirds of all elementary and secondary school teachers receive no such training at present. IBM has responded by donating $25 million in awards to colleges that devise innovative ways to educate prospective and current teachers in classroom technology.

This same effort must be applied on a national scale. State governments should be encouraged to revise teacher certification requirements to include training in the use of computers for instructional purposes. Computer training should also become part of state professional development mandates.

Similarly, teacher support should include a new school professional, the "educational technologist," who is skilled in the use of hardware and appropriate software. Postsecondary institutions should be encouraged to develop a curriculum that will graduate the educational technologists needed in schools.

Tie Educational Technology into Current Federal Initiatives

A federal/national effort must be made to ensure that educational technology and the use of computer-based instruction become part of the administration's AMERICA 2000 proposal. This can be achieved through appropriate Congressional support and encouragement.

Specifically, persons well-versed in educational technology should serve on the Research and Development Teams. Computer-based instruction must also be a requirement for use in the new generation schools. Educational technology should become part of the administration's efforts in educational choice, because computer-based instruction can be a key factor in promoting competition among schools participating in a educational choice effort.

The U.S. Chamber's Center for Workforce Preparation and Quality Education stands ready to assist in this federal effort to pursue nationwide implementation of policies called for in AMERICA 2000. The Chamber can carry word of AMERICA 2000 policies to the local level through its 2,900 member chambers of commerce. After all, education restructuring can only take place through a cumulative effort where all communities work toward education improvement and the incorporation of technology learning systems. State and local chambers can be the catalyst, because they provide a common bridge between business, education, and parental leaders in every community across the United States.

CONCLUSION

If American industry is to be competitive -- and if our national economy is to be viable -- we must have a sophisticated and highly trained workforce. The incorporation of computer-based learning systems in schools across the nation can help private industry meet this challenge. By working with government and community leaders, business has made great strides in initiating a campaign to make technological learning environments commonplace. But much more needs to be done.

By considering the recommendations described above, and by working closely with the Bush Administration, Congress can play a major role in ensuring that educational technology becomes part of this decade's education reform movement. The U.S. Chamber of Commerce stands ready to assist Congress in this most critical endeavor.

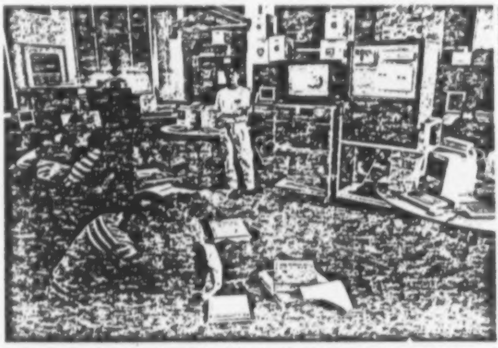
COMPUTERS COME OF AGE IN CLASS

And VCRs, laser discs, and telecommunications systems too. Electronics makes learning relevant. It does not make teachers irrelevant. ■ **By Nancy J. Perry**

STEVE JOBS remembers vividly the day he began to understand supply and demand. As a 12-year-old visitor to a NASA research center, he started fiddling on a computer with a game called King Hammurabi, in which the player rules over an imaginary kingdom for ten years. Weighty decisions were called for: how much grain to grow, how much money to spend on soldiers, how high to raise taxes. Jobs found if he fed people well, the population grew. But if he didn't store enough grain and was hit by a drought—trouble. Says Jobs, who graduated from playing videogames to co-founding Apple Computer and then starting Next Inc.: "You're learning the underlying principles of macroeconomic theory, and it's a blast."

Two decades later, most educators have come to believe that computers can utterly transform the way children are taught. Why? Because they make learning fun for children raised on *Sesame Street*, Nintendo, and MTV. Says Gordon Brown, retired dean of engineering at MIT: "Competition for kids' interest today is fantastic, so in school they are bored to death." Added benefits: Computer-based learning is active, not passive, and promotes the skills business says it values most—problem solving, teamwork, and familiarity with technology.

Corporations from AT&T to Lockheed are donating equipment and helping teachers tap the power of technology. Now students can plug into distant databases, communicate with schools abroad, simulate moon landings, and watch John F. Kennedy being sworn in as President. Leading the electronic bandwagon are Apple and IBM. Apple has provided over $60 million in computers and equipment to schools since 1979 and spends millions more each year researching the impact of technology on teaching and learning. Over the same period, IBM has donated $50 million in computers and training, and plans to spend another $50 million over the next five years. Mattel recently started giving computers to learning-disabled students in Los Angeles in what it expects to expand into a nationwide program. Thanks to Southern New England Telephone, teachers in Connecticut are communicating with parents through a voice-mail system.



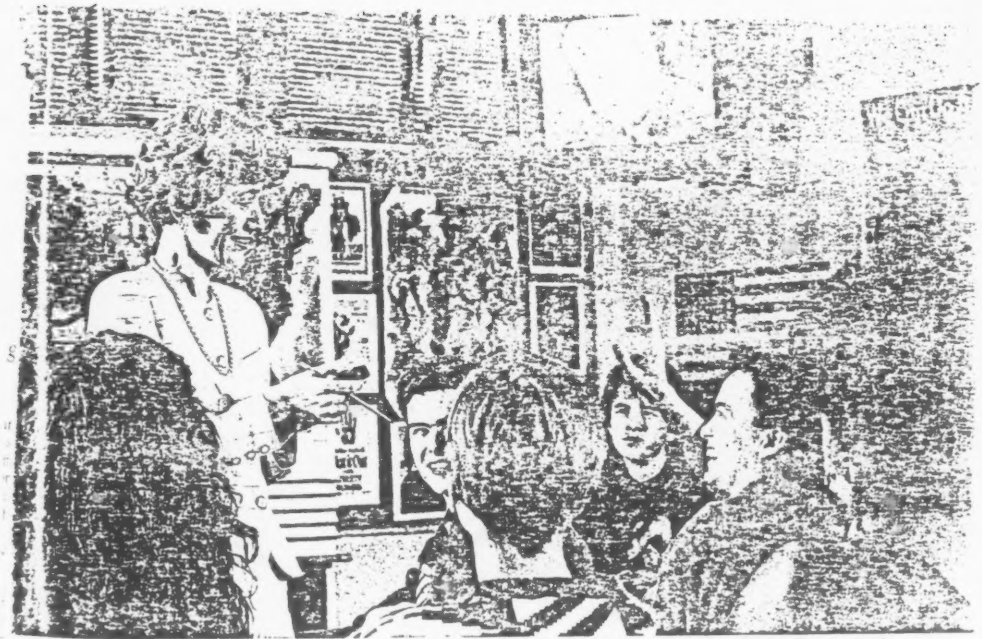
Biology class at this Columbus, Ohio, high school is a real multimedia experience.

Want to see a classroom of the future? Step inside Frank Draper's exuberant eighth-grade life sciences class at Orange Grove Middle School in Tucson, Arizona. Students sit in pairs, each twosome sharing both an Apple-donated Macintosh and a science project. Draper roams from desk to desk, answering questions, offering advice and acting as a coach.

Josh Hagan and Adam Harant have just designed a 1,132-square-foot energy-efficient house, located in a deciduous forest. After researching energy conservation techniques, the boys specified concrete construction with 12 inches of fiberglass insulation and ultra-low flush toilets to save water. A simulation shows that to keep the thermostat at [illegible] degrees all year, the boys will have to spend $3,0[illegible] on heating and cooling costs. They decide to cut their energy bills by removing a few windows and adding more ceiling insulation—changes that keep them within their $100,000 budget. "This takes a lot of thinking," says Josh. "But it's so much fun, you want to work on it during lunch."

In Draper's class computers do amazing things, such as figure a year's energy consumption in five seconds. Most teachers, however, still use the machines primarily to drill and practice the basics: reading, writing, and math. Artificial intelligence techniques could soon make computer instruction more effective. Intelligent tutor

REPORTER ASSOCIATE *Lorraine Carson*



Interactive video brings American history to life at Centennial High School in Corona, California. Says a Centennial teacher: "This is a TV generation."

systems, which analyze a student's problem-solving process, can sense when the child is having trouble and offer advice.

Los Angeles investment banker and philanthropist Richard Riordan, 60, has become sort of a modern-day Music Man, hoping to solve the trouble in Education City by showering schools with computers. Why? Says he: "Because they work."

Having reviewed scores of programs that teach young children, Riordan has become a champion of IBM's Writing to Read. The software, now in use in 5,000 schools nationwide, first encourages children to write words the way they sound—"kat" or "thru"—and later pairs the words with the correct spellings.

Two years ago Riordan got a call from Mississippi Governor Ray Mabus, who expressed his desire that every child in the state read and write by the end of first grade. Last November, Mississippi kicked off a $13 million five-year program to install Writing to Read labs in every kindergarten and first grade in the state by 1993. Riordan and his childhood buddy Richard Dowling, president of RORD Foundation in New York, donated $1.5 million to the project and pledged another $5.5 million; the legislature agreed to kick in the remaining $6 million.

BY ALLOWING children to progress at their own pace, providing immediate feedback, and not passing judgment on slow learners, computers can be particularly helpful in teaching learning-disabled youngsters. Says Karen McMahon, who teaches such students at Jefferson Elementary School in a poor Hispanic neighborhood in Los Angeles: "The computer is much more patient than I am. I'm also not as motivating. They think this is a game. I'm a teacher, not a game."

Jefferson is one of five schools that received free Writing to Read labs from Mattel. As McMahon talks to a visitor, some children prance around her, showing off their work, while others run from computer to computer. At the far end of the room, Edward, 10, sits intently before a terminal, typing away. The teacher and her aides watch him in amazement; while Edward is a good reader, they haven't been able to get him to write a word. A peek at the screen reveals a well-organized essay describing a recent class trip to a restaurant. It concludes: "Mrs. McMahon is the best teacher you could have. If you do, you will be lucky." Computers can supplement, but never substitute for, a good teacher.

Critics once worried that technology would isolate students from each other and the teacher; just the opposite has proved true. Television and telecommunications are connecting classroom teachers with one another, and inner-city schools and rural districts are linking up with the outside world. For example, both Whittle Communications and the Cable News Network offer lively colorful daily news programs for high

✓ **FACT**

According to the Office of Technology Assessment, 95% of American schools have one or more classroom computers and roughly 90% have VCRs. Nearly all the states have educational TV and electronic communications projects under way.

school students. Whittle's 12-minute program, *Channel One*, is controversial because it includes two minutes of commercials; schools like it because Whittle, which is 50% owned by Time Warner, the parent of FORTUNE's publisher, throws in free TV monitors, VCRs, wiring, and satellite dishes as part of the deal. Ted Turner's 15-minute *CNN Newsroom* comes free of advertising but free of equipment as well.

In Connecticut, telecommunications is promoting parental involvement in the schools. For the past two years, 34 schools have been participating in a trial program called SNET Links to Learning, developed by Southern New England Telephone in cooperation with the state department of education. A popular feature is VoiceLink, which encourages teachers to keep in touch with parents by voice mail.

Teachers in most schools communicate with parents primarily through written notes that end up at the bottom of the book bag. With voice mail, the teacher can record individual messages for each parent during lunch or after class, and the parents can respond when they have time. They just pick up their Touch-Tone phone, dial a central number, and then punch in a personal identification code to get a message or leave one.

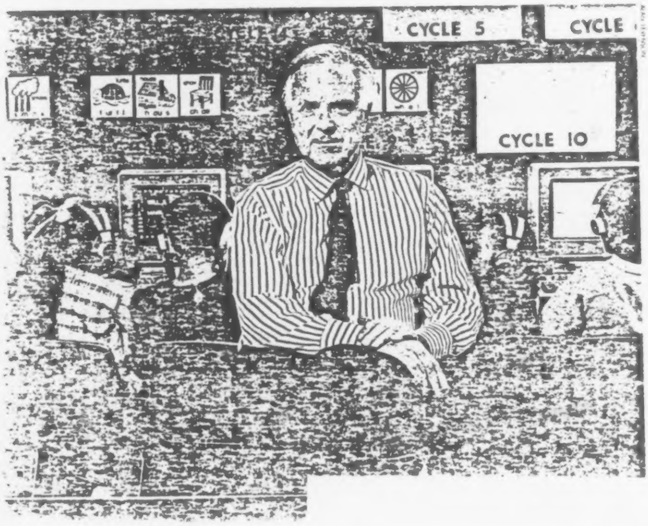
Joan Heffernan, a teacher at Buckingham Elementary School in Norwich, says she used to talk to parents once a year at parents' night. Now she commonly has as many as ten messages waiting for her at the end of the day. Because the SNET experiment will be over in June, Heffernan is frantically applying for grants so that the school can keep the VoiceLink system. Says she: "I've become very dependent on it."

Telecommunications also brings advanced science and math to rural students, like those at West County High School in Leadwood, Missouri, a relatively poor town 70 miles south of St. Louis. Three years ago Leadwood installed a $9,000 satellite dish so that the school could receive such programs as scientific lectures sponsored by Talcott Mountain Science Center in Avon, Connecticut. Asks school superintendent Claude Lynch: "What's our chance of getting Neil Armstrong or Carl Sagan to come to our school?"

Imagine spending a day listening to arias from Mozart's *Don Giovanni*, browsing through the Louvre—lingering over the *Mona Lisa* and the *Venus de Milo*—and taking a trek through ancient Mayan ruins, stopping at times to inspect the most curious artifacts. Through multimedia—a combination of interactive videodiscs, compact discs, digital audio, and laser scanners—students can do all this and more.

The enormous storage capacity of laser discs and compact disc/read-only memory devices (CD-ROMs) allows schools to house entire libraries of information that, unlike textbooks, can be updated every six months. Compton's, a subsidiary of Encyclopaedia Britannica, in conjunction with Josten's Learning Corp., offers a 26-volume talking encyclopedia on a single compact disc that includes 15,000 still pictures, animation, magazines, and charts, and lets children hear former President Richard Nixon say, "I am not a crook." Cost: $895.

Businessman Richard Riordan has given IBM Writing to Read labs to 350 classrooms in five states.



MULTIMEDIA MAGIC is routine at Centennial High School in Corona, California. With the help of $250,000 in equipment donated by AT&T, Centennial has recently become the first school in the U.S. to install a fiber optics-based wide-band video switching system, which is capable of simultaneously transmitting high-quality video programs to up to 48 classrooms at once. Each class has a wide-screen monitor, so a teacher could show, for example, chapter six of *CEL Communications Video Encyclopedia of the 20th Century*. It presents TV footage of Martin Luther King's eerily prescient "I've Been to the Mountaintop" speech in Memphis the night before he was shot. Says Tom Wilson, director of educational technology for the Corona-Norco Unified school district: "How can you put the charisma of Martin Luther King in a book?"

If computers are so great, why haven't they caught on even faster? Mainly because of poor hardware, software, and maintenance in the early days. Still, even with the advent of computer networks, good programming, and multimedia, questions about effectiveness linger. Reliable data on the impact of computers on student performance are scarce and mainly anecdotal. Apple is spending several million dollars a year on Apple Classrooms of Tomorrow (ACOT), a long-term research project that studies the impact of technology on teaching and learning. The company provides students and teachers in 20 U.S. classrooms with computers for school and home use, and funds university researchers to study the ACOT classrooms.

Preliminary results have been generally positive: ACOT beneficiaries appear to be better writers and more independent learners than students without such computer access. But evaluators caution that ACOT schools are too high tech to represent the average school. In fact, one researcher, Steven Ross at Memphis State University, has shown that many students who leave the ACOT program and return to classes w out computers lose their educational edge. Says Ross: "When you give somebody a car and take it away, it doesn't mean that person can walk faster. The idea that the computer is going to change a child cognitively needs further support."

Designing software for the education market continues to be tricky. Complex pedagogical issues emerge. Will computers make students lazy? What skills does a child really need to know? Must he learn to draw a graph, or just to interpret one? Says Apple researcher Wayne Grant, who is currently grappling with such issues: "With matches, we lost the skill of building a fire by rubbing two sticks together. But I'm not sure that's a skill we need to preserve." Even dicier: how to test what the student has learned. Today's standardized tests, like the SATs often required for college entrance, do not measure the skills computers supposedly teach, such as critical thinking. The Educational Testing Service has committed $38 million over five years to develop computer-based testing tools.

Frank Draper's students in Tucson prefer computers to lectures.

Even the most sophisticated hardware and software programs are useless if teachers do not know how to use them. According to the Office of Technology Assessment, only one-third of elementary- and secondary-school teachers have had as much as ten hours of computer training. IBM has responded by establishing a $25 million program that awards some $200,000 to colleges that come up with innovative ways to bring teachers up to speed on classroom technology. So far 75 schools have received grants.

For its part, Apple has formed the Christopher Columbus Consortium, a partnership of six school districts and six colleges of education, to explore ways of using technology to improve classroom instruction. The company has given more than $2 million of equipment to the group, with the stipulation that it must match the gift dollar for dollar.

A serious worry about the computerization of the classroom: It will widen the gap between the haves and have-nots. In its study, the Office of Technology Assessment found that students in poor schools have less access to computers than their peers in richer schools have, and that blacks have less access than whites. In a recent computer competency test conducted by the Educational Testing Service, white students on average answered 47.6% of the questions correctly, vs. 40% for Hispanics and 39.9% for blacks.

Still, the biggest barrier to a technological revolution in the schools is cost. American schools have only one computer for every 30 students. To reduce that ratio to 1 to 3, the Office of Technology Assessment estimates that the U.S. would need to spend an extra $4 billion annually for years.

Corporate America is filling some of the need. Last year in California, Pacific Bell, IBM, Lockheed, and other corporations successfully lobbied the state legislature for $14 million to support technology in schools. Last September, the Cable Alliance for Education—a consortium of 28 of the country's largest cable programmers and operators—pledged to provide all junior and senior high schools with free cable installation and basic service by the end of 1992.

What might the future bring? Jack Taub, creator of the Source, a collection of computerized databases, thinks he can dramatically lower the cost of getting computer and video programs to the classroom. Taub envisions information flowing into the schools like gas and electricity, with users paying only for what they need. Now head of a company in New York City, he has patented a system, the Education Utility, to make that happen.

HERE'S HOW IT WORKS. The Utility's national computer control center in Memphis will provide access to all kinds of educational software, databases, and interactive videos. Whenever a teacher wants one of these, he simply orders it from the Utility. Overnight a satellite beams the program to the school's central computer, where it remains for as long as the school needs it. Schools pay only for the time they use the programs; the Education Utility covers the royalties to software manufacturers and other information suppliers.

If all goes according to plan, the system should pay for itself. Taub's idea is to let people in the community—college students, small businesses, parents, local organizations—call up programs in the central computer after school for a fee of $1.50 an hour. Revenues would be split three ways: One-third would go to the software supplier, one-third to the Utility, and one-third to the school. The school could use the money to pay for the system. The Utility will reserve part of its share to help rural schools that will have fewer community users.

Taub is a missionary: "And the Lord said 'Thou shalt beat swords into workstations.' " But he is a visionary too, and smart people are beginning to listen to him. Governor Bill Clinton of Arkansas thinks Taub's idea has potential, as does New York City schools chancellor Joseph Fernandez. In Arizona, the Utility is already running in a Phoenix high school and on a Navaho reservation.

One day in April, Dick Lewis, a teacher from Moon Valley High School in Phoenix, was visiting the Utility's local office. Moon Valley is planning to spend some $300,000 to install the Utility; the school district projects community access fees will bring in roughly $50,000 to $70,000 per year. Lewis, 58, can't wait to get the program going; he feels that rather than reducing the role of the teacher, technology will enhance it. The thought makes him wistful. "It's mind-boggling what we'll be doing with this in ten years," he says. "In two years I can retire. I don't think I'm going to." ◻

Mr. **Valentine**. Thank you, sir; thank all of you.

Let me ask Dr. Fortune, if you would give us, Doctor, some estimate, if you can, of the cost, the volume in machinery, and the approximate cost of this technology; if that is not an unreasonable inquiry?

And, also—well, I'll ask you that first.

Dr. **Fortune**. Sure. One of the issues would be how pervasive we would want to have the computers in schools. Right now you have the model of the labor versus the classroom, because of cost, a lot of computers going into schools are going into labs, and typically you will have one to two labs, 30 to 60 computers in a given school.

A lot of us are hopeful, in order to do a better job of involving the teacher, that we will push the technology right into the classroom. So, let's say, you're looking at a lab of 30 stations and, irrespective of the hardware that we might suggest, you're talking about, say, a thousand to $1800 per station.

So we're looking at for a lab of 30 stations—and when we say 30, we're thinking in terms of one per student in a laboratory setting—we're looking at 30 to $40,000. And then in addition to that, you'd want adequate software. Software—depending on the type of software, can go any way—anywhere—from another 2500 up to another 30,000 for that lab of 30 stations.

Mr. **Valentine**. Now, when you—the first figure that you mentioned, that was for the lab of 30 stations?

Dr. **Fortune**. That's—that's for the lab approach.

Also in my testimony, I wanted to make the point, and a part of the recommendation of the 68 stations, six to eight stations in a classroom, I'm very hopeful that, again, we will push the technology to the classroom so that we can do a better job of involving the classroom teacher.

And in that model you might want to look at anywhere from six to eight stations per classroom.

Mr. **Valentine**. Do you envision that a well-equipped and well-provided for school would utilize computer-based instruction entirely, a hundred percent of the time, 50 percent, 75 percent?

Dr. **Fortune**. I think entirely is sometime to come, and I don't know that any of us know at what point in time. Certainly one of the questions that has been raised, at what point will computer technology, computer-based instruction, say, go so far as to replace the textbook, as an example.

I don't envision that happening in my lifetime. I do think what we'll see will be an increased amount of time way beyond what we're doing today, in a wide variety of ways. One example: Instead of teachers using the chalkboard to do presentations, I've been in many classrooms where teachers are now using the computer with a big screen projection to project the image.

And just imagine in an area such as mathematics or science—and one of the contributions that computer technology, multimedia technology contributes to the area of mathematics and science is to make those very abstract qualities of math and science concrete for students.

So, I see a lot of alternative ways in which a teacher will present materials in which students will use it but not necessarily to the point that for eight hours a day a student will be, say, banging away at the computer station.

Mr. **Valentine**. Of course, it's not intended that this would take the place of books.

Dr. **Fortune**. Absolutely not. I see them really working in concert.

Mr. **Valentine**. Let me—I want to come back to you, but I must ask Dr. Houlihan this question: If at the time when you were Superintendent in Granville County when I came to—to that school system and we went in the room with all those computers lined up, was that a computer-based instruction situation like we're talking about here?

Dr. **Houlihan**. Very definitely. Yes, it was. And if you remember, our goal was to have students on—every student in that school system on the computer every day. As—as a tool, though; not to replace the teacher, and really not to replace the curriculum, but as a tool to help student—students—develop those basic skills.

Mr. **Valentine**. And you sit for at least part of the time, you bring the—the children in and they sit there and they deal with that computer on a 1-on-1 situation, don't they?

Dr. **Houlihan**. That's correct, and you could have literally 28 different students at 28 different places in terms of instruction. But the key is what the teacher then does with what happens in that lab back in the classroom.

If it—if it's a stand-alone situation, it's not nearly as effective.

Mr. **Valentine**. Is there a difference between, Dr. Fortune, what that average student could accomplish working with that computer on an individual basis, and not knowing that there was somebody back in the classroom who was going to giggle if the student made a mistake—is there a difference as to what a student might be able to accomplish under those circumstances and what that same student could do with the same problem, having gone through it several times, in the classroom exposed to all of the outrageous good humor of young folks, and let's face it, and the cruelties?

I don't know why they were made that way, but they were—they'll say anything about anybody and don't care anything about anybody's feelings; call you dummy or whatever.

What I'm really trying to say is, is there a difference between what you can do with this computer and what you're able to do when you go back into real life?

Dr. **Fortune**. Yes, Mr. Chairman, the—there have been a number of studies that looked at the transferability of skills learned in a computer-based instruction setting and the carryover that that will have not only to the classroom and making these youngsters much more confident, but also in terms of their performance on various types of achievement tests.

Let me also point out, not only is this a great concern of students but also of adults. Some of the best applications of computer-based instruction that I've had the opportunity to see would be those adults whose reading skills are very poor, who have been very hesitant to go back and learn for the very reasons that you are pointing out. But when having the opportunity to go to a computer-based instruction system, as you said, it's very private, can make mistakes; the computer is patient, you can take your time; it makes a big difference.

And—and much more importantly, and one of the contributions that computer-based instruction and technology in general can make is that you can mold the instruction to the student at the level in which he or she might understand. And that is such a big contributions. When you have 30 students in a class, it's virtually impossible for the teacher to reach out and work with all of the students at their various levels, even if they're similar—even if they have similar ability levels.

Mr. **Valentine**. One of the reasons I asked that question is because I am well aware with a disease known as stage fright—and I have it myself. And I always—when I went to Raleigh to present my superb argument to the North Carolina Supreme Court. And I stood up and faced those seven judges, the best argument was always the one that I made going back home, remembering things that I didn't say to them.

What about the Japanese? We always come back to that question. What can you tell us about what the Japanese people have to tell us about this situation?

Dr. **Fortune**. In preparation for this hearing I conducted an extensive search to try to find out what was going on internationally, and I came across several articles as to what was occurring in Japan in terms of computer-based instruction.

Interestingly enough, they are approximately five to ten years behind the United States. Now we don't want to get too comfortable because at the other end of the spectrum—and this is in terms of kindergarten through 8th grade instruction—by the time you get to the high school and at the college level, there are some very interesting examples of the application of technology that are taking place, particularly in the area of science, mathematics, and engineering at the secondary level and at the—at the college level.

Also in Japan, we have schools known as juku, which are typically schools in the afternoon, where you have not only the instructional day going on for six hours, but typical another two to three hours after the regular instructional day; and the use of computer-based instruction is finding it's way into these jukus throughout Japan.

But it's fair to say, that the United States is by far the leader in the use of computer-based instruction computer-based technology for instructional purposes.

And—and another point to be made is, part of the reason is because of the difficulty in terms of the language, you know, the use of symbols in Japan and China, has held back the development and use of computer-based instruction. But that's about to change.

New technology is coming on that will recognize images and handwriting, and I think that you'll see an acceleration in the use of computer-based instruction in Japan as a result of this new technology.

Mr. **Valentine**. Let me ask this question to the panel generally. At what age would it be practical to start attempting to instruct young folks with this type of equipment? Kindergarten?

The reason I asked that is because, you know, I think we would all have to admit that one of the greatest problems in this society is what happens to these little minds before they get to the school. What happens to them as a result of, you know, inattentive parents or those people who stand in locus parentis, whether it's grandparents or whatever, and in environments that where there is no incentive and no encouragement. As a matter of fact, in the environment where any degree of learning would be discouraged from the beginning.

When could you really start to address that problem?

Dr. **Fortune**. Sure, I'd be glad to.

There's never an age that's too young to—to start a student. At—we have software from a variety of companies that now reaches down to preschool level—three-year-olds, four-year-olds. And what's interesting, I've talked with a lot of kindergarten teachers, a lot of school administrators, and often they will say, well, can you get these kindergarten youngsters to use the mouse, you know, the input device?

And what's interesting, it's really the teachers and the administrators who have the difficulty coordinating the mouse, not the kids. Typically, kids, through video games and other means, are well-versed and well-coordinated at manipulating the mouse. So—

Mr. **Valentine**. That's the—that's the reason I call my—the seven-year-old kid from next door to tell me how to rig up that VCR. We couldn't figure out the instructions. This kid was able to do it.

Dr. **Fortune**. Well, there's another interesting study—more than 80 percent of VCR owners cannot program their VCR, so you are in very good company.

Mr. **Valentine**. What percentage?

Dr. **Fortune**. Greater than 80 percent.

Mr. **Valentine**. Okay.

Mr. Shanker, how large of a problem is—is the business of resources for teacher training in the proper use of educational technologies even when the computers and software is available?

Mr. **Shanker**. Well, it's a very big problem because training takes time and time is money. If you do it doing school time, it means that you need other teachers to take the place of these teachers. If you do it during some other time, you're going to pay for both the trainers and you're going to pay for those being trained.

And school districts across the country now, if you follow the headlines, you're watching this morning layoffs in New York—not just the city, but around the State; and Connecticut. California hasn't got a budget yet. Illinois doesn't; Massachusetts, Florida. So when you're talking about laying people off and increasing class size and freezing salaries, and everything else, about the last thing that's going to be on anybody's priority list is how we're going to create time for this sort of—sort of training.

So that's—that's—that is a very important problem.

But I also think there's another one, and that is that training people for something they're going to be doing later and there's not—often not very effective. I think what you frequently have to have is—if you had the hardware and software there, and then had resources so that the people who needed it could reach on a practically day-to-day basis, that's a lot more helpful than getting something six months before the stuff comes in where somebody's going to abstractly tell you what's going to be there.

It's a—it's just like, well, the kids learn it through doing and also the teachers, and so do all other adults. And you get a tremendous amount of loss if you treat this as an academic exercise. And I think that's part—part of the problem with—with training is that we've got a wrong—wrong notion of what it should be like.

Mr. VALENTINE. Mr. Shanker, in your testimony you spoke about giving schools incentives, which would be needed to urge them to move along.

What can you—describe in more detail what you meant by that.

Mr. SHANKER. What I'm talking about, incentives both for the adults and for youngsters. We just heard that Japan is far behind us in terms of using technology and yet, they do so well.

Well, the Germans are far behind us, too, and so are the French, and so are the British, and every other nation in the world whose kids are far out in front of us, are up to now not doing very much with technology.

That's not an argument against technology , but we ought to say, well, why are they succeeding without the use of technology?

Well, they're succeeding to a large extent because the parents and the youngsters in those countries know that if they don't do well in school there are going to be dire consequences. In Germany, if you don't pass a certain national examination, you don't go to college; and you don't pass that unless you know how to read your language very well and write it very well, and unless you know mathematics at a pretty good level, and science, and the history of your country. And parents know that, and teachers know that, and the kids know that, and so they work for it.

In Japan, you know that—what you do or the kind of job you're going to get with a company eventually is going to depend on a very rigid system of merit, as defined by them.

And so that's a system of incentives. And essentially it shows that even if you don't have the technology , even if you use old-fashioned methods that humiliate youngsters, and get them—that if you've got strong incentives, people will keep working.

Now the two types of incentives you need are essentially you need incentives for youngsters that make them go through the hard work and effort that it takes to learn something, and they're only going to put in that hard work if there are rewards and punishments connected to that, in addition to the intrinsic excitement and enjoyment, which you can get a lot more out of in some of—in terms of some of the technology that's available.

As far as the adults are concerned, I think what you need is a system in which each school is considered an independent unit. Don't measure or check the schools every year because if you do you're just going to test kids to death and nobody's going to go through the trouble of really changing the school if they know they've got to produce results in one year.

Give people time to try things out. Give them time to learn themselves. Give them time to, if something doesn't work, to recover. Give them three, four, or five years. But I would say that if you had a system where every four years or so you measured school improvement—what percentage of our kids used to be able to write a good letter, what percentage can write one now. What percentage used to be able to write an essay, or were able to solve mathematical problems of a certain type.

And then have large rewards for the schools that have increased achievement; not the ones that started high and ended high, but the ones that started and moved up.

Now if you were to do that for 10 or 15 percent of the schools in this country every four years, you could create rewards like 20, 30, 40, or even $50,000 for every professional within that school without it's costing an awful lot of money.

On the other hand, at the—at the—at the other end, the far—I would have smaller rewards for those who had smaller achievement. I'd have normal cost-of-living increases for those who a little below that. At the far bottom, where schools actually moving backwards or doing nothing, I'd have something that's equal to a hostile takeover and a loss of positions.

Now, if you had a system like that, we wouldn't have to be sitting here asking ourselves why isn't there any technology in the schools. If you put that system into effect tomorrow, what are the people in that school going to do? They're going to sit down and ask, how can we, as a team, win this thing four years from now?

And they'd start saying, well, do we need some different teachers? Do we need some technology? Are we better off when three teachers retire, or are we better off using technology, or replacing them? Or are we better off hiring 30 graduate students to come in and do tutorial work?

In other words, get people to make intelligent judgments. Get them to constantly look at what results do we get from technology; what results do we get from this; what results do we get from that.

The only way you're going to get people to constantly look at what works and what doesn't work is if it makes a difference to them. And right now we've got a school system in this country where if you succeed, it makes no difference to you; that is, you get your intrinsic enjoyment. But the chances are if you succeed, everybody around you will say you're cheating, it won't work anywhere else, you get dumped on. And if you fail for years, nothing happens either.

And I say for both the kids and the adults, you essentially—there have to be consequences. And that links up to the world of business also. I think we need businesses that hire on the basis of—if you had McDonald's and Roy Rogers and Pizza Hut asking every high school kid who comes in for an afterschool job, show me your report card and bring me a letter from your teacher saying that the work you're doing in school is so excellent that you can afford to work every afternoon or evening; if the kids learned in school that what they're doing there is valued by the business community—not 10 years later, but right then and there—I think that you'd get a different attitude towards learning.

Mr. **Valentine**. I have to ask all of you if you care to comment on, to what extent do you think the national organizations of teachers are concerned about the problem that you just described?

I know this might get in to a touchy area and an area that is—may be ran naked into politics—but until at least recently, I noticed resistance from some, if not most of the school teachers in my district, to a method of testing teachers. And I think that sooner or later we're going—we're going to have to start with that project I think as a national plan because we're going to have to find some way, in my judgment, to weed out those people who are not willing to move into the area that you gentlemen have described to us here.

Would you care to comment on that, Mr. Shanker, or anybody else?

Mr. **Shanker**. Well, we've been in favor of teacher testing. We like to test them before they come in instead of having them teach 20 years and then test them and decide that you shouldn't have had them for the last 20 years, that—

But before they do—and we're very much in favor of it. But there are several issues in teacher testing. You've got a lot of teacher testing across the country right now.

But the real question is, what level does a person have to achieve in order to become a teacher?

Now, because of the fact that we don't produce very many people in this country who are good at reading, writing, or mathematics, even those states that have teacher testing, hire people who achieve at very low levels. They don't tell that to the public; they just say that person passed the teacher test. But what does it mean they pass the test? Not much in most places.

And, you know that Texas retested teachers, and Georgia retested teachers, and Arkansas retested teachers. You know how many teachers in those States passed? Oh, about 99.9 percent. You know why 99.9 percent passed? After they looked at the results, they asked themselves, could we afford to let these people go; do we have anybody waiting for these jobs is any better?

So let's face it; there is nobody out there waiting in line with outstanding skills and language, science, and mathematics who wants to be a teacher. And there's no point in testing the people you've got unless you've got somebody to replace with.

Mr. **Valentine**. I realize that this leads us off the path and I'll try to come back. But I must say, making a parting shot, that I've received a questionnaire within the past year from a national teachers organization, perhaps the teachers organization, and the questions on that questionnaire, two-thirds of them were addressed to social questions and other matters involving one's attitude toward abortion and that kind of thing, and had very little to do with what teachers in that organization should be concerned with, that is, how to deliver the best possible job in the classroom.

Well, Mr. Joseph, in your testimony you recommend that we focus national attention on the need to equip students with technological skills for the—for the work force.

How, in your opinion, could we make learning more relevant to the skills students will need in the work force?

Mr. **Joseph**. We believe that business people in their communities need to be sitting down with local boards of education, local school boards, and talking through what their community employment needs will be.

In other words, if—if a widgit manufacturer needs certain skills to keep his factory operating and—and he or she discover for a number of years people are coming through the system without those skills, they basically may be in a position, not necessarily to give an ultimatum, but to basically say to the local community, if we can't find a way to produce people who know how to use these technologies, these machines, these applications, for the next four or five years, we're going to probably have to take our factory someplace else, maybe to a different country where they know how to do those things.

Well, obviously, no one's trying to force that, but what we're trying to do is get a better mix and match, a better personal interrelationship with the local business people, sitting down with local school boards to talk about what their needs are and how you get people there.

Mr. **Valentine**. Dr. Tuscher, what are, in your opinion, are the danger areas in this technology , and how do we deal with them?

Dr. **Tuscher**. Could you repeat that question, Mr. Chairman?

Mr. **Valentine**. What—for example, looking at the perhaps loss of competitive motivation, the impersonalization of the—of the learning process, what are the danger areas, such as these and perhaps others, and how do we deal with it?

Dr. **Tuscher**. I think one that you mentioned having to do with the impersonalization, I—I believe unless we change the use of technology that is a reality of a problem that needs to be addressed.

New technology such as the digital technologies, which I addressed, provide opportunities for a collaborative learning, cooperative learning in a technological environment. Most of the learning that takes place with technologies today is individually based with the student and the machine. This needs to be remediated and I think that can be with the new technologies which are being advanced.

Another danger of the technology I think is to—some of the experiences I've seen in the schools and some of the teachers who have passed through our institution in terms of training, is—is the use of technology without some directed outcomes and the use of that technology, and see the benefits of the technology, yet they're using the technology because some of it is exciting, some of it is motivating. And unless we can demonstrate as a few systems can be demonstrated, the productivity of these technologies, that's probably the greatest danger is utilizing resources in a way which are not productive.

Mr. **Valentine**. Thank you, sir.

Thank you, gentlemen, very much for the time that it took you to prepare yourselves and for otherwise preparing and for coming to share these words of wisdom with us.

Let me remind everyone here, that while we were approaching the end of the testimony, some young folks paraded into this arena from these two doors and they're ready to demonstrate to all you old fogies the latest techniques.

So with that, the subcommittee will stand adjourned, but I hope that everybody who can will stay and avail themselves of the knowledge that is here on both sides of the room.

Thank you.

[Whereupon, at 1:02 p.m., the subcommittee was adjourned.]

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